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WEEKLY 30 March 2024

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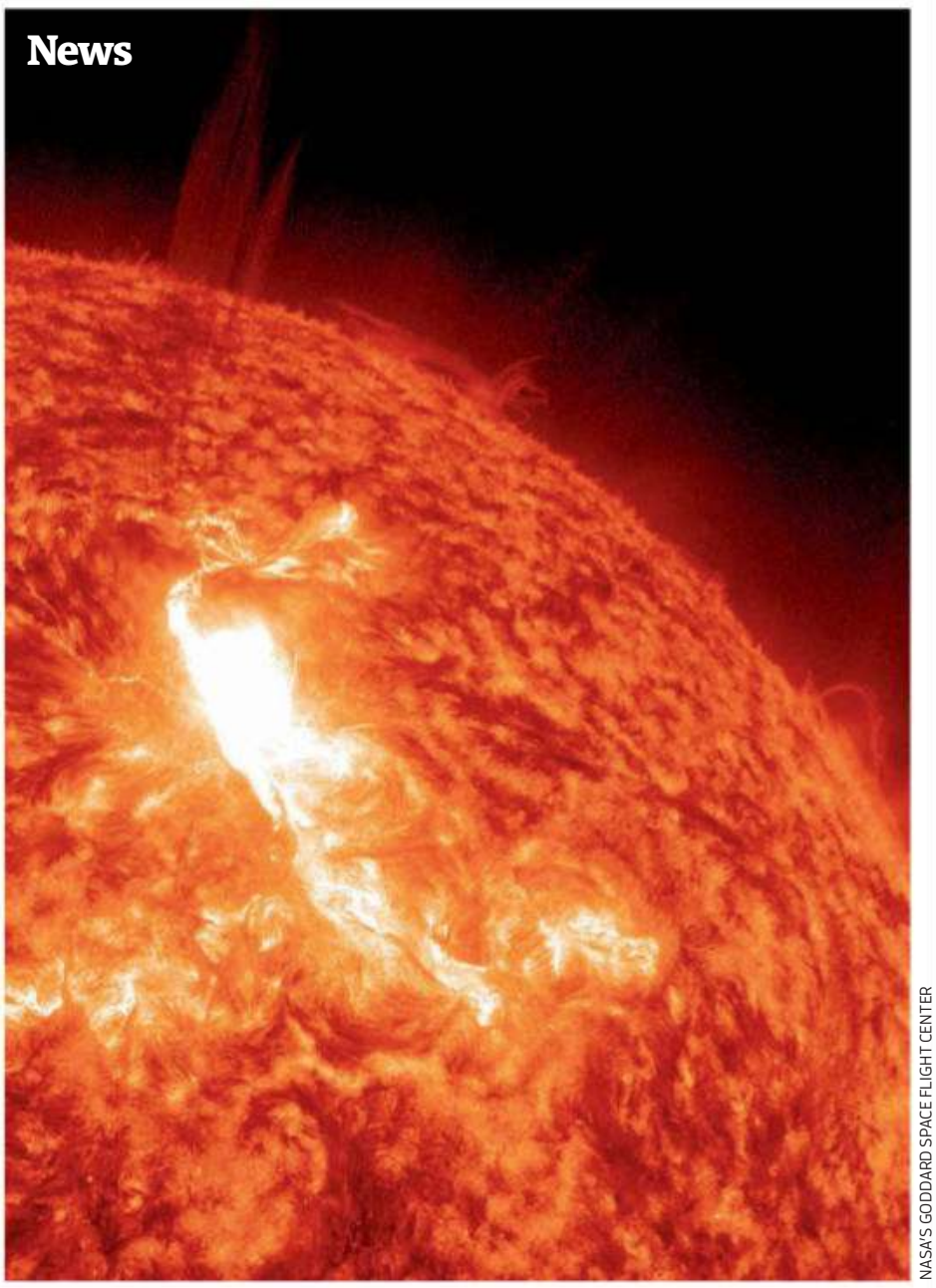

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Online event

The neuroscience of memory

The ability to store memories and relive each moment in detail is vital to our lives. But remembering is about reconstruction rather than a literal act of reproduction. In this free, subscriber-only online talk, neuroscientist Jon Simons will explore how the brain captures memories and how they are rebuilt when they are recalled. Join us on 4 June at 6pm BST/1pm EDT.

newscientist.com/events

Tour

Ancient caves, human origins: Northern Spain

Discover some of the world's oldest known cave paintings by torchlight in an idyllic part of Spain, including El Castillo, Las Monedas, La Peña, El Pindal and Tito Bustillo. Join former *New Scientist* editor-in-chief Emily Wilson to explore how our ancestors lived, played and worked 40,000 years ago. This seven-day tour starts on 18 June and costs £3250.

newscientist.com/tours

JOSH MCINNES (CC-BY SA 4.0)

Intelligent hunters Orcas corral sealions into ocean canyons

ART2010/ALAMY

Ancient paintings What does art tell us about our ancestors' minds?

Podcasts

Weekly

The team discuss how chipmaker Nvidia wants companies to use its chips to create AI-powered humanoid robots. Hear how a group of orcas is using a new hunting strategy in the open ocean. Plus, planet-gobbling stars and an incredibly well-preserved archaeological site that has got ancient Britain enthusiasts excited.

newscientist.com/nspod

Video

Turn back time

Anti-ageing has become a multibillion-dollar industry built on promises to make us live longer and look younger. But how close are we really to extending our lifespan by many years? Nobel prizewinning molecular biologist Venki Ramakrishnan speaks to *New Scientist* features writer Graham Lawton about insights offered by molecular genetics.

youtube.com/newscientist

Newsletter

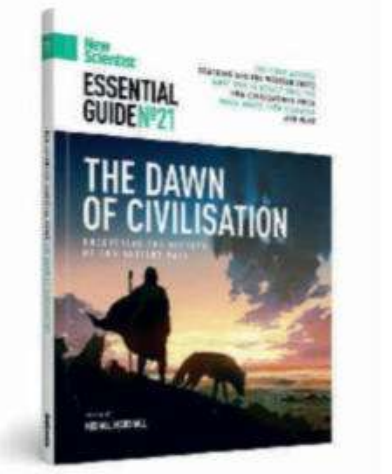
Fix the Planet

Swapping out polluting gas boilers for electric heating systems is one of the key milestones for achieving net-zero emissions. But progress in the UK and US is worryingly slow. Environment reporter Madeleine Cuff considers what they can learn from other countries.

newscientist.com/fix-the-planet

Newsletter

"Most of us don't think about our heating system. We just want to feel warm"



Essential guide

Where are the origins of humanity? When did civilisation begin and what does the future of society hold? Uncover the secrets of the past in this *New Scientist Essential Guide* covering all that we know about the arc of human ingenuity. Now available to read in the app or buy in print from our online shop.

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The future is grey

An ageing world will compel us to change how we live

MUCH is made of intergenerational conflicts, with boomers pitted against millennials or Gen Zers. But however these competing needs are resolved today, in the future, younger people will become an increasingly prized resource, because there will be fewer of them.

Populations are slowly being skewed older than ever before by two seemingly unstoppable demographic forces. One is that, as countries become more prosperous, there is a decline in the number of children that people have. When that figure drops below the population replacement level of 2.1 children per woman – unless offset by immigration – the head count shrinks, as well as becoming more senior-heavy. If this trend continues, 97 per cent of countries are forecast to have birth rates below the replacement level by the year 2100 (see page 13).

The other key factor is that people are living longer in nearly every country in the world, a trend that has continued for decades. This has been driven by multiple factors, including improvements in sanitation, the spread of vaccines and antibiotics, and, later on, by better treatments for heart disease and the decline of smoking. The next reshaping of life expectancy curves could come from the widespread use of weight-reducing drugs such as Ozempic and Wegovy, or indeed medicines already in wide use today (see page 8).

"Ageing populations force countries to rethink their pension and healthcare systems"

These ageing populations present many challenges, forcing countries to rethink their systems of pensions, healthcare and so on. The risk is that there will be too few people of working age to help provide and care for those who are older.

But we shouldn't necessarily be too pessimistic. Just like in medicine, advances in artificial intelligence (see page 17) and robotics (see page 7) are continuing apace. Could the potential demographic crisis be averted by a workforce of intelligent machines? If so, rather than having to be worried about robots taking our jobs, we might one day welcome them with open arms. ▮

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FOR DISCERNING TRAVELLERS

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ART & OPERA IN LISBON

A FOUR NIGHT HOLIDAY | 8 MAY 2024

Lisbon, 'City of the Navigators', was once the heart of Europe's maritime power and memories of this Golden Age are still clearly evident today. Our four-night tour will uncover one of Europe's liveliest cities, we shall also make excursions to the nearby towns of Sintra and Queluz. A performance of *Falstaff* at Lisbon's wonderful 18th century opera house, the Teatro Nacional De São Carlos, will be a highlight.

Price from £2,376 (single supp. £280) including two dinners, three lunches, and a First Category ticket for 'Falstaff'

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18 APRIL & 26 SEPTEMBER 2024

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Price from £2,995 (single supp. £490) including six dinners, two lunches and a wine tasting

CARCASSONNE & ALBI

SIX NIGHT HOLIDAYS
13 MAY & 23 SEPTEMBER 2024

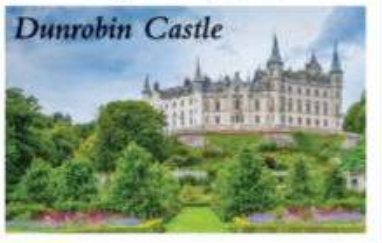
This tour is based at the pinnacle of the mediaeval citadel of Carcassonne where we stay at the luxurious Hotel de la Cité, built into the ramparts with panoramic views of the countryside. It is from here that we will explore the many distinctive regions of this beautiful part of southwest France. The precipitous mountain strongholds, majestic abbeys and breathtaking scenery all come alive as our tour lecturer Simon Monckton unravels the region's complex history.

Price from £2,986 (single supp. £594) including three dinners

GLORIOUS GARDENS OF THE SCOTTISH HIGHLANDS

A FIVE NIGHT HOLIDAY | 17 JUNE 2024

Despite its northerly latitude, the Highlands of Scotland, warmed by the effects of the Gulf Stream and cultivated by some of the country's most skilled and passionate horticulturalists, is home to a surprising diversity of gardens. In the company of local expert Paddy Scott, we will visit a number of private gardens, some of which are rarely open to the public, and enjoy guided tours with the owners and gardeners themselves.



Price from £2,896 (single supp. £350) including five dinners and four lunches

BORDEAUX: WINE CAPITAL OF THE WORLD

A FOUR NIGHT HOLIDAY | 18 OCTOBER 2024

The elegant city of Bordeaux has become a byword for fine wines over the course of many centuries, but many of the estates here are still small producers, often in the hands of ancient families. In the company of wine writer Jonathan Ray, we will meet experienced winemakers in person, and go behind-the-scenes to sample exceptional wines and enjoy truly memorable dining experiences.

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News

Staying afloat
Canoe study hints at Mediterranean trade 7000 years ago **p11**

An idea with bite
Ant queens have good reasons for eating their young **p11**

Crop conundrum
Organic farmers may boost pesticide use on nearby farms **p15**

Tissue repair
Some antibiotics seem to regenerate animal heart cells **p16**

Big game mode
DeepMind AI advises on football tactics for corner kicks **p19**

Technology

Nvidia bets big on humanoid bots

Flanked by a squad of robots, this is Jensen Huang, CEO of chip-maker Nvidia, addressing the firm's artificial intelligence conference in San Jose, California, on 18 March. At the event, Nvidia announced new software and hardware as part of its focus on developing an AI model to help humanoid robots learn more efficiently.

DAVID PAUL MORRIS/BLOOMBERG VIA GETTY IMAGES

Health

Drugs with anti-ageing influence?

Four commonly taken drugs, including Viagra and medicines containing oestrogen, seemed to slightly lower the chance of people dying during a 12-year study, finds **Clare Wilson**

FOUR widely used medicines have emerged as possible life-extending drugs, after an analysis of UK health records found they were each linked with slightly lower chances of dying during a 12-year study.

The medicines are Viagra, for erectile dysfunction; atorvastatin, used to lower cholesterol levels; an anti-inflammatory and pain-killing drug called naproxen; and oestrogen, a component of hormone-replacement therapy (HRT).

"I wouldn't say that the lifespan effects could be explained by a healthier lifestyle"

The idea that existing prescription medicines could have life-extending effects on top of their known uses has a long history (see "Lifespan boosters", below). "We don't want to cure or treat a single disease, we want to prevent many of them," says Alejandro Ocampo at the University of Lausanne in Switzerland.

Such effects can be hard to find, because any small benefits to lifespan may be outweighed by the negative impact from the condition for which the drug is prescribed, says Ocampo, who has also co-founded a biotech firm called Epiterna, aimed at developing anti-ageing compounds. Ocampo's team investigated the extent of these benefits by using data collected through UK Biobank, a large study following the health of about half a million people.

The largest difference in death rate was seen in women taking medicines containing oestrogen, mainly HRT products. These were linked with about a 25 per cent lower death rate over the study than in similar women who didn't take the hormone.

As HRT improves bone strength, it could be keeping people alive longer by reducing their chance of breaking a hip, which can be very dangerous in older people due to the necessary surgery and long recovery period, says Richard Faragher at the University of Brighton in the UK. There were also significant but somewhat lower effects seen in people taking Viagra (sildenafil), atorvastatin and naproxen (MedRxiv, doi.org/mnhw).

SIMONKR/GETTY IMAGES

Some everyday medications may cut our risk of dying early

When it comes to how these drugs may improve longevity, Viagra has recently been linked with a protective effect against Alzheimer's disease. Statins reduce heart attacks and strokes, while naproxen dampens pain by lowering inflammation, which is suspected of playing a role in a wide range of conditions.

The findings can't be taken as proof that these medicines make people live longer, as it wasn't a randomised trial – the best kind of medical evidence – but just found correlations between taking each drug and a lower chance of death over the study period.

The correlations could have arisen because people who are healthier to begin with are more likely to use Viagra, for instance. The researchers tried to tweak their data to take account of such factors. However, "there can always be biases that are difficult to control for", says Joao Pedro Magalhaes at the University of Birmingham in the UK.

But some of the drugs had a larger benefit on lifespan when taken at higher doses, which seems to support the effect being real, says Ocampo. "I would not say that could be explained by a [healthier] lifestyle."

One surprise was that the analysis didn't find a lower risk of death linked with taking the diabetes medicine metformin, which has been suggested to extend lifespan in some previous studies, although not all. ▮

Lifespan boosters

Viagra, atorvastatin, naproxen and oestrogen may have life-extending properties (see main story), but they aren't the first medicines thought to have such effects on top of their usual benefits. Here are three others:

- **Metformin** is a drug for type 2 diabetes that suppresses the amount of blood sugar made by the liver. Some studies suggest that people taking this drug for diabetes live longer than those without diabetes. It may have an anti-ageing effect by killing cells that are "senescent" and have become dormant, which release harmful signalling molecules.

- **Rapamycin** is given to people after organ transplants because, at high doses, it suppresses the immune system. Animal studies suggest that, at lower doses, it inhibits a compound called mTOR, believed to regulate the ageing process.

- **Gliflozins** are drugs used to treat type 2 diabetes because they cut the amount of sugar reabsorbed by the kidneys, causing more of it to be excreted in urine. These seem to extend lifespan in other animals, and studies in humans suggest they reduce long-term, low-level inflammation, thought to play a role in several ageing processes.

Zoology

Dogs understand that certain words stand for objects

James Woodford

RECORDINGS of dog brain activity suggest they understand that words represent specific objects.

Although some dogs can fetch a wide range of different objects on command, few do well on such tests in the lab. To explore if dogs understand words as object names, rather than as instructions, Marianna Boros at Eötvös Loránd University in Budapest, Hungary, and her colleagues assessed 18 dogs from a range of breeds, including Border collies, toy poodles and Labrador retrievers.

GRZEGORZ ELIASIEWICZ

One of the dogs that participated in the brain scanning study

Each owner chose five objects familiar to their dog. In the test, they said the name of an object and then showed the dog either the named object or a different item.

Boros and her colleagues used electroencephalography (EEG) to monitor each dog's brainwaves to see whether there was a difference in activity when the dog's owner said "ball", but showed a stick, for example, compared with when the word and object were the same.

The EEG signals were different when the objects didn't match and the effect was stronger for words that the dogs knew well (*Current Biology*, doi.org/mnr7). This is similar to results seen in humans.

"The most important realisation of this study is not only that non-humans are capable of understanding words referentially, but this capacity seems to be generally present in dogs as well," says Boros. No breed appeared to show a greater language ability than any other, she adds. ▮

Environment

Food is costing more due to climate change – and prices will keep rising

Michael Le Page

YOU are already paying more for food due to global warming, and rising temperatures will drive food prices much higher in the next decade.

According to a study done in collaboration with the European Central Bank, by 2035, higher temperatures alone will be pushing up worldwide food prices by between 0.9 and 3.2 per cent every single year. This will add between 0.3 and 1.2 per cent to overall inflation.

"There's often a sense of shock and surprise at the magnitude of these impacts," says Maximilian Kotz at the Potsdam Institute for Climate Impact Research in Germany, referring to his discussions with economists while doing the study.

Warming-fuelled extreme weather is increasingly affecting food production and if farmers don't adapt, the losses will become ever more serious as the world continues to heat up.

To find out how this is altering food prices, Kotz and his colleagues compared data on the monthly prices of a range of goods and services in 121 countries between 1996 and 2021, along with the weather conditions those countries were exposed to.

The researchers looked for correlations between food prices and factors such as the average monthly temperature, the temperature variability and measures of drought and extreme rainfall. They found a strong link between the average temperature and the food prices a month or so later.

In regions that were north of 40 degrees – the latitude of New York City, Madrid and Beijing – warmer-than-average temperatures during winter led to falling food prices. But in summer and at all times in the rest of the world, above-average temperatures increased food prices (*Communications Earth & Environment*, doi.org/mnsc).

What's more, the effects on prices are long-lasting. "Once the prices have increased on the basis of one of these shocks, they stay higher for at least the rest of the year," says Kotz.

The study didn't look at why prices rose, but the likely explanation is that extreme heat is reducing yields, he says. "Crops may be drying out on the vine when they should be being harvested." Factors such as extreme rainfall had less impact on food prices than average temperatures, says Kotz. This may be because flooding tends to be localised, whereas above-average temperatures can be very widespread.

Other studies have reached similar conclusions, says Kotz. However, his team then went further by investigating how food prices could change based on average temperature rises in climate model projections. In the team's worst-case emissions scenario, global food inflation due to climate change exceeds 4 per cent per year by 2060. However, many other factors could change by then, so the team regards its projections for 2035 as more reliable.

Global warming won't help Argentina's already high food prices

JUAN MABROMATA/AFP VIA GETTY IMAGES

3.2%

Higher temperatures may make food prices rise this much a year

"There are many things that can happen that will change the way in which the economy responds to climate shocks," says Kotz. For instance, if farmers adapt their practices to better cope with rising temperatures, the inflationary pressures would be reduced. But, so far, there is no sign that farmers are doing so, he says.

"I feel that these are realistic projections. They build on solid, empirical evidence," says Matin Qaim at the University of Bonn in Germany. "We need to be aware of the fact that climate change brings huge new challenges for food and nutrition security." ▮

Briefing

Human receives pig kidney

In a medical milestone, a genetically modified pig kidney has been successfully transplanted into a living human, reports **Grace Wade**

SURGEONS have transplanted a pig kidney into a 62-year-old man living with end-stage kidney disease. As *New Scientist* went to press, the recipient, Richard Slayman, was recovering well and was expected to be discharged from the hospital within days.

Is this the first ever pig kidney transplant?
This is the first time a pig kidney has been transplanted into a living human, which makes it a significant milestone in the field of xenotransplantation, or the transfer of animal organs to humans. "The success of this transplant is the culmination of efforts by thousands of scientists and physicians over several decades," said Tatsuo Kawai at Massachusetts General Hospital in a statement. "Our hope is that this transplant approach will offer a lifeline to millions of patients worldwide who are suffering from kidney failure."

Strictly speaking, however, this isn't the first ever pig-to-human kidney transplant. The procedure has been performed five times in the past, all in people who were declared brain-dead and kept on life support. The most recent of these took place in July 2023 by Robert Montgomery at NYU Langone Health and his colleagues. That kidney functioned for more than a month without signs of rejection or infection.

When did the surgery take place?
Kawai and his colleagues performed the surgery on 16 March. The procedure lasted 4 hours, and the kidney began producing urine and the waste product creatinine soon after, according to reporting by *The New York Times*. Slayman has also been able to stop dialysis, a further indication that the kidney is functioning well.

Where did the kidney come from?
The organ was provided by the pharmaceutical company eGenesis, which breeds pigs genetically engineered to carry certain human genes and to lack a particular set of pig genes that are harmful to humans. These genetic modifications reduce the likelihood of transplant rejection, when the immune system attacks the organ and causes it to fail. Slayman is also receiving a cocktail of immune-suppressing drugs to further lower this risk. So far, there is no sign of rejection and Slayman is able to walk on his own.

What do we know about the recipient?
Slayman has type 2 diabetes, high blood pressure and kidney disease. He had previously received a human kidney from a donor in December 2018. However, the organ showed signs of failure about five years later. He started dialysis in May last year, but experienced complications, requiring visits to the hospital every two weeks.

More than 100,000 people in the US are waiting for an organ transplant, 17 of whom die each day. The US Food and Drug Administration authorised the experimental transplant for Slayman due to a lack of other treatment options. "I saw it not only as a way to help me, but a way to provide hope for the thousands of people who need a transplant to survive," said Slayman in a statement.

Have there been similar procedures with other organs?
Only two other people have undergone a xenotransplant, both of whom received a genetically modified pig heart. The first, a man named David Bennett, died two months later, potentially due to complications from a pig virus called porcine cytomegalovirus. So, scientists genetically inactivated this and similar viruses in the pig that Slayman's kidney came from.

The second recipient, a man named Lawrence Faucette, died from transplant rejection six weeks after his surgery. ▮

MICHELLE ROSE/MASSACHUSETTS GENERAL HOSPITAL

The pig kidney being removed from its box to prepare for transplantation

Technology

Robot designs better paper planes than a human

Alex Wilkins

A ROBOT can design, build and test objects made from folded paper, such as planes, better than a human if given the same number of attempts.

Robotic laboratories can test and design materials far faster than humans, but they often rely on computer simulations to cut down on real-world testing for the robot. However, this doesn't work when testing objects that are difficult and computationally expensive to simulate, such as fluids or deformable materials like paper.

Now, Ruoshi Liu at Columbia University in New York and his colleagues have developed a robotic testing platform, called PaperBot, that can design objects made from paper without needing computer simulations.

"We wanted to design tools in the physical world directly, instead of in the simulation, because in this way we can model many more realistic behaviours that are hard to simulate," says Liu.

To make a plane, the robot is first given a rough outline for a folded paper design, but is allowed to vary the length and width of the wings. The robot then folds the plane, chooses a launch angle and throws it. After measuring how far it flies, the robot adjusts the design using a machine learning algorithm and tries again.

"PaperBot works very similarly to how humans do things," says Liu. "We try random, different designs and then our memories remember what the good ones and the bad ones look like, and we try to find a pattern there."

After 100 trials, which took about 3 hours, PaperBot's best plane design flew further than the best plane designed by a person given the same number of attempts at optimising the wing design before letting the robot arm throw it (arXiv, doi.org/mnsk). ▮

Archaeology

Bustling sea trade 7000 years ago

Ancient canoes capable of transporting goods suggest Mediterranean trading in the Neolithic period

Christa Lesté-Lasserre

MORE than 7000 years ago, skilled craftspeople constructed wooden canoes that probably transported people, animals and goods across the Mediterranean Sea.

A re-analysis of five boats with signs of seafaring technology, such as transverse reinforcements and towing accessories, hints that they probably enabled trade and transportation among Mediterranean farming communities during the Neolithic period, says Niccolò Mazzucco at the University of Pisa in Italy.

Along with the well-preserved village they were found in, the canoes "open a window to the past", he says.

In 1989, Italian researchers discovered the site – which they named La Marmotta – buried under a lake 38 kilometres from the Mediterranean coast, slightly north-west of Rome. In addition to multiple wooden buildings, they found dugout canoes built from trees that had been hollowed by burning and carving.

Nearly all information on them has been published only in Italian, so they weren't well-known internationally, says Mario Mineo at the Museum of Roman Civilization in Rome, who participated in the discovery.

GIBAJA ET AL., 2024, PLOS ONE, CC-BY 4.0

These long canoes, almost 10 metres from end to end, are made from hollowed-out trees

Now, Mazzucco, Mineo and their colleagues have taken a fresh look at the canoes and shared their results in English.

Lasse Sørensen at the National Museum of Denmark is intrigued by wooden T-shaped devices found with the canoes. The holes drilled into them suggest they were probably used for ropes, which implies the boats were towed, says Sørensen. "These details are really important because they're actually a testimony of how they could have transported a lot of goods."

"Recent tests of replicas confirmed that the originals would have been seaworthy"

The team carbon dated the boats to the 6th millennium BC: the two oldest were built as early as 5620 BC and the most recent one as late as 5045 BC. Carbon dating one T-shaped accessory revealed it was made as early as 5470 BC (*PLoS One*, doi.org/mnsm).

The boats are up to 10 metres long. This size suggests they were used on the sea, says Mazzucco. Recent tests of replicas confirmed that the originals would have been seaworthy. Foreign grains, livestock remains and stones found at the village indicate the villagers traded across the Mediterranean region.

Microscopy analysis of samples revealed that two of the canoes were made from alder, which is lightweight and doesn't split or crack easily. The most recent boat was made from oak, which is tough and resistant to decay, while the remaining two boats were made from poplar and beech.

"They probably had enough knowledge about wood species and their properties to choose them and to use them on the basis of those properties," says Mazzucco. ▮

Animal behaviour

Ant queens have good reasons for eating their young

WHEN black garden ant queens notice their young are sick, they eat them before the illness spreads. This behaviour gives us insights into the evolution of "filial cannibalism", the practice of parents consuming their offspring.

Ants and other colony-dwelling social insects usually remove or isolate sick nestmates. But ant queens start their colonies alone, so how do they defend against disease? To find out, Flynn Bizzell and Christopher Pull at the University of Oxford collected newly mated black garden ant queens (*Lasius niger*) and took their larvae away once they began establishing a colony. The researchers exposed some of the larvae to spores of the lethal *Metarhizium* fungus, which infects wild ant nests. After they had time to develop infections that would become fatal, but weren't yet contagious, the team returned all the larvae to the queen.

The queens ate 92 per cent of their sick young, but only 6 per cent of the uninfected larvae, showing they could detect the infection and intervene (bioRxiv, doi.org/mnjr).

NIK BRUINING/SHUTTERSTOCK

A black garden ant colony in its nest with a few eggs, pupae, larvae and a large queen

The queens that eat their infected larvae seem to avoid harm, perhaps by swallowing their own antimicrobial venom to make their guts hostile to fungal spores, the researchers suggest.

"If the queen gets infected and dies, the colony dies," says Sebastian Stockmaier at the University of Tennessee, Knoxville, since she is the only reproductive individual. So, it makes sense that an evolved strategy for dealing with disease would emphasise the survival of the queen.

Eating the sick larvae yields other benefits too. The queens that ate their sick young went on to lay 55 per cent more eggs than those that didn't, suggesting they had recycled those calorific resources. ▮

Jake Buehler

Zoology

World's hairiest beetle

An eye-catching insect found in Australia is impressively coiffed

James Woodford

THIS fluffy find could be the world's furriest beetle. It was spotted by entomologist James Tweed from the University of Queensland, Australia, when he was camping in 2021 at Binna Burra Lodge in Queensland's Gold Coast Hinterland.

Emerging from his tent, he saw what he thought were droppings on a plant. But on closer examination, he saw it was actually a spectacular, 1-centimetre-long red and black beetle covered in hair, which was especially thick around the top half of its body.

He quickly realised it was a type of longhorn beetle – a family with around 36,000 described species – but there was nothing comparable to it that was known elsewhere. It has been designated as a new genus and species named *Excastra albopilosa*, which translates to "from the camp, white and hairy" (*Australian Journal of Taxonomy*, doi.org/mnjh).

JAMES TWEED

Space flight

Starship accidentally caused volcano-like blast

WHEN SpaceX's Starship rocket launched for the first time in 2023, it destroyed its launch pad in an explosion similar to a volcanic eruption, sending huge chunks of concrete high into the sky.

"It was eye-opening to us that launch pads could explode so violently," says Philip Metzger at the University of Central Florida.

Metzger and his colleagues have studied the test flight and found that the explosion couldn't be explained by the exhaust and fire from the rocket engines alone. "These were giant pieces of concrete travelling at 90 metres per second, making splashes in the ocean that were 20 metres high," says Metzger. "If it was just the gas forces of the rocket exhaust, it would not have accelerated these large chunks to that velocity."

The researchers found that what happened was similar to a type of volcanic eruption in which pressure builds up beneath a plug called a caprock, which eventually explodes. In this case, the caprock was the concrete launch pad. The pressure was caused not only by the hot gas from the rocket engines, but also because groundwater under the pad turned to steam and expanded, blasting the concrete upwards (arXiv, doi.org/mnh2).

After the blast, a fine drizzle of small debris particles settled over the surrounding area, lofted more than 10 kilometres away from the launch site. The researchers found that this was mostly sand from the ground underneath the launch pad.

"If you go to the moon and you damage your rocket engines like they did here, then you can't get back"

The explosion was unusual because nearly all launch pads have built-in mitigation features, such as flame trenches or systems to inject lots of water onto the pad. SpaceX's pad wasn't equipped with any of this. SpaceX didn't respond to a request for comment.

"The goal was to test the rocket and the launch pad was secondary," says Paul van Susante at Michigan Technological University. "Now they've installed a big steel plate, they've installed a water deluge system, so this failure is not likely to happen ever again." Indeed, SpaceX's two subsequent tests didn't blow up the launch pad.

"This really underlines the need for the right landing and launch infrastructure on the moon and Mars if we want to have a permanent presence there," says van Susante. "If you go to the moon and you damage your rocket engines like they did here, then you can't get back."

Leah Crane

Why falling birth rates will be a bigger problem than overpopulation

Nearly every country is predicted to have a birth rate that is too low to maintain its population by 2100, which may result in too few people of working age, says **Clare Wilson**

THINK of global population problems and you might think of the growing number of people in the world – currently about 8 billion – and our collective toll on the planet. But due to people having fewer children as countries become more prosperous, the real demographic problem may turn out to be falling populations.

Projecting from current trends, demographers have now predicted that, within about 25 years, three-quarters of countries will have birth rates that are too low to maintain their populations. While this may be good news for the environment, having fewer working-age people to support those who are older presents a huge economic challenge.

The latest projections also indicate that there will be a sharp divide between countries with low birth rates and generally high incomes – such as most European nations – and a smaller number of countries, mainly in Africa, with higher birth rates and low incomes.

"We are facing staggering social change through the 21st Century," researcher Stein Emil Vollset at the University of Washington in Seattle said in a statement. "The world will be simultaneously tackling a baby boom in some countries and a baby bust in others."

Demographic time bomb

Maintaining economic and societal stability in the face of these stark differences will be one of the key challenges of this century. So what should countries be doing to prepare for this demographic time bomb?

While the trend of a rising global population has long caused environmental concerns, demographers also knew it wouldn't continue indefinitely. Estimates vary, but we seem on course to hit "peak people" sometime between 2060 and 2080, with a head count of 9.5 to 10 billion people, falling thereafter.

2.1
Number of children that must be born per woman to keep a population constant

76%
By 2050, this proportion of countries are projected to have birth rates below the 2.1 level

97%
By 2100, this proportion of countries are projected to have birth rates below the 2.1 level

The latest projections from Vollset's team are broadly in line with previous predictions from bodies such as the United Nations in terms of global trends. What is new is a more detailed breakdown of how things will change country by country, based on the latest data on birth rates for five-year age groups from those aged between 10 and 54, projected to the year 2100.

Countries generally require a birth rate of 2.1 children per woman for their populations to stay constant. Vollset's team found that, by 2050, the birth rate will have fallen below this level in 76 per cent of countries. By 2100, this is forecast to be 97 per cent (*The Lancet*, doi.org/mndp).

At the same time, people are living longer, so populations as a whole have fewer people of working age who can help provide for older people and others who are economically inactive. An ageing population cannot be avoided, says Vegard Skirbekk at the Norwegian Institute of Public Health in Oslo. "However, one should try to make the transition slow in order to better be able to prepare for this process."

To slow falling birth rates, high-income countries should attempt to make it easier and more attractive for people to have more children, for instance by improving access to housing and fertility treatments, says Skirbekk.

Change of focus

Countries also need to plan to cope with their shrinking and ageing populations by building more hospitals, updating transport systems and having fewer schools, says Melinda Mills at the University of Oxford. "Cities are focusing on getting people to schools and to work. They might have to focus more on getting them to shops and hospitals."

Jennifer Sciubba at the Wilson Center, a think tank in Washington DC, says companies also need to make it easier for older people to stay in work for longer, for instance, on reduced hours. "We have this binary view that you're either working or not, but that doesn't have to be the case," she says.

A minority of countries, however, face the opposite challenge of having a higher birth rate than the 2.1 replacement level. The new study finds this will probably still be true even in 2100. Most such nations will be in sub-Saharan Africa and are projected to account for one in every two children born by 2100.

In these countries, better access to contraception and education for girls have been shown to reduce birth rates, says Sciubba. Migration from high-birth-rate and low-income countries is also likely to continue, which could lead to competition between higher-income nations for migrants from sub-Saharan Africa, the authors of the new study say in their paper. "However, this approach will only work if there is a shift in current public and political attitudes towards immigration," they say. ▮

The birth rate in China has dropped sharply in recent years

COSTFOTO/NURPHOTO/SHUTTERSTOCK

Archaeology

Human brains mysteriously preserved for thousands of years

Michael Le Page

A STUDY of human brains that have been naturally preserved for hundreds or thousands of years has identified 1300 cases where the organs have survived even when all other soft tissues have decomposed. Some of these brains are more than 12,000 years old.

"Brains of this type, where they're the only soft tissue preserved, have been found in sunken shipwrecks and in waterlogged graves where the bones are just floating," says Alexandra Morton-Hayward at the University of Oxford. "It's really, really strange."

"We're not expecting a brain to preserve in any type of environment, to be honest," she says. "If, as an archaeologist, I dig up a grave and I find a brain rattling around in a skull, I would be shocked."

Many researchers have noted that human brains are found preserved more often than expected and in surprising circumstances, says Morton-Hayward. Now, she and her colleagues have done the first ever systematic study of the phenomenon. They have put together a database of more than 4400 preserved human brains found all over the world (*Proceedings of the Royal Society B*, doi.org/mnd3). They have also collected and studied many preserved brains themselves.

In most cases, the brain preservation could be explained by known processes. For instance, the brains of Incan human sacrifices entombed on top of a volcano in South America around AD 1450 were freeze-dried along with the bodies, says Morton-Hayward.

The bodies and brains of bog people such as Tollund Man, who was hanged and dumped in a bog 2400 years ago in what is now Denmark, were preserved by a tanning process similar to that used for leather.

GRAHAM POULTER

Alexandra Morton-Hayward holding a 1000-year-old brain

And saponification, where fatty substances turn into a form of soap called grave wax, preserved the brains of some people shot in 1936 during the Spanish Civil War.

12,000

Some preserved brains date back this many years

But the known processes preserve all soft tissues, not just brains. They don't explain the 1300 cases where brains are the only soft tissue to survive.

"This unknown mechanism is completely different," says Morton-Hayward. "The key feature of it is that we only have the brain and the bones left. There's no skin, no muscle, no gut."

For instance, Saint Hedwig of Silesia was buried in Poland in 1243. When her body was exhumed in the 17th century, her brain was found to be preserved, which at the time was attributed to divine power.

Morton-Hayward thinks that, in certain circumstances, substances such as iron can catalyse linking between proteins and lipids, forming degradation-resistant molecules, and that this affects brain tissue preferentially.

"The mechanisms are similar to those that we see in neurodegenerative diseases, like dementia," she says. "So if we can figure out what's happening to brains after death, we might be able to shed some light on what's happening in brain ageing in life as well."

The study is important because preserved brains are often the same colour as soil, says Brittany Moller at James Cook University in Melbourne, Australia. "It is therefore highly likely that brain material is frequently discarded during archaeological excavation as it is not recognised for what it is." ▮

Zoology

Extinct freshwater dolphin was the largest of all time

Corryn Wetzel

THE Amazon basin was once home to freshwater dolphins that grew up to 3.5 metres long – making them the largest river dolphins known.

During a 2018 expedition in the Peruvian Amazon, a fossilised skull was spotted poking out of a river embankment, says Aldo Benites-Palomino at the University of Zurich in Switzerland. Analysis showed it was from a dolphin but unlike any previously found.

Benites-Palomino and his colleagues have now named the species *Pebanista yacuruna*. The name honours a mythical aquatic people – the Yacuruna – believed to inhabit underwater cities in the Amazon basin.

The 16-million-year-old fossil was unearthed in a region that was once covered by a lake that was "insanely big – almost like a little ocean in the middle of the jungle", says Benites-Palomino. Based on the small size of the ancient dolphin's eye sockets and its large teeth, he says *P. yacuruna* was probably a predator with poor eyesight, and relied heavily on echolocation to find fish. "We know that it was living in really muddy waters because its eyes started to reduce in size," says Benites-Palomino.

Because the fossil was found in the Amazon basin, the researchers expected its closest living relatives to be modern Amazon river dolphins. Instead, they found *P. yacuruna* was more closely related to river dolphins of South Asia. Like them, this ancient species has raised crests on its skull that improved its ability to echolocate (*Science Advances*, doi.org/mnd4).

***P. yacuruna* may have been driven extinct during an ecological shift, says Benites-Palomino. "Around 11 to 12 million years ago, this mega wetland system started to drain, giving way to the modern Amazon. A lot of species disappeared at that moment."** ▮

Agriculture

Organic farms can boost pesticide use

Spillover of insects seems to prompt nearby conventional farmers to change their behaviour

Madeleine Cuff

ORGANIC farmers produce food with minimal help from pesticides, but in curbing the use of chemicals on their own land, they may unwittingly be triggering a spike in pesticide use over their neighbour's fence.

Ashley Larsen at the University of California, Santa Barbara, and her colleagues assessed land-use and pesticide data across 14,000 fields in Kern County, California. This is one of the largest crop-growing counties in the state, with produce including almonds, grapes, carrots and pistachios.

The researchers found that when organic farmland is surrounded by conventional agriculture, neighbouring farmers seem to increase their pesticide use, with a 10 per cent rise in organic cropland being linked to a 0.3 per cent increase in total pesticide use on conventional fields. Most of this is driven by greater use of insecticides, the researchers found.

This may be because more insects – pests or otherwise – tend to live on organic land and spill over into neighbouring fields, prompting conventional farmers there to increase pesticide use, Larsen told reporters during a press briefing. The effect appears strongest when neighbouring fields are within 2.5 kilometres of the organic "focal field".

Conversely, the researchers noted that the presence of organic farmland is linked to a reduction in pesticide use on neighbouring organic fields, with a 10 per cent increase in the area of surrounding organic cropland being associated with a 3 per cent decrease in total pesticide use on organic focal fields (*Science*, doi.org/mnhn). This may be because the larger area of organic farmland allows for a bigger and more stable community of beneficial insects.

Most of the farms in Kern County, California, are conventional ones

INGA SPENCE/ALAMY

Organic agriculture only covers about 2 per cent of farmland globally, but in Kern County, about 5.5 per cent of agricultural land is organic. When organic agriculture makes up a high proportion of farmland – perhaps 20 per cent or more – net pesticide use decreases regardless of where the organic fields are sited, say the researchers.

But when small areas of organic farmland – like in Kern County – are evenly dispersed through the landscape, net pesticide use may in fact be higher than when no organic farming is present.

"Our simulations suggest that at low levels of organic agriculture in the landscape, we can actually see an increase in net insecticide use," said Larsen.

However, this impact can be mitigated by clustering organic farmland together to minimise potential pest spillover, she said. "It might be worth considering, at the policy level, how to incentivise spatial clustering of new organic fields to basically leverage the pest control benefits of organic and limit any potential costs of organic on conventional growers."

Robert Finger at ETH Zurich in Switzerland says the findings show the need for authorities to consider land-use policy at the "landscape scale". "Thinking about single fields or single farms is not enough," he says. ▮

Physiology

Why teens make noses wrinkle but infants smell sweet

TEENAGERS seem to produce chemicals in their sweat that lead to body odour with notes of urine or musk. The finding could lead to more effective deodorants.

Helene Loos at the Friedrich-Alexander University in Germany and her colleagues looked into how body odour changes between early childhood and adolescence, when hormonal changes are associated with an increase in body odour.

The researchers recruited 18 children aged up to 3 years old along with 18 teenagers aged 14 to 18. The participants were all washed with a fragrance-free gel before going to sleep with cotton pads sewn into the armpits of their clothing.

Next, the researchers extracted the chemicals absorbed by the pads and used a technique called mass spectrometry to identify them. They then used gas chromatography and a trained assessor to sniff out the odorous ones. "The human nose is used as a detector," says Loos.

Overall, the chemicals responsible for the two groups' body odour were similar, but those from the teenagers contained higher levels of several carboxylic acids, which the assessor described as "cheesy", "musty" and "earthy".

The researchers also identified two steroids that were exclusive to the teenage samples, which smelled of "urine and musk" and "sandalwood and musk", respectively. The findings may show why infants are generally considered more pleasant smelling, they write (*Communications Chemistry*, doi.org/mnhj).

"Steroids that were exclusive to teenage samples smelled of urine, musk and sandalwood"

Further research into the scents we produce at different ages may help scientists develop more effective odour control, says Loos.

Andreas Natsch at the fragrance manufacturer Givaudan in Switzerland says the study only evaluated body odour over one night, and the picture could change over a longer period. "The more pungent odours of adults develop upon emotional or physical stress." ▮

Larissa Fedunik

Health

Common antibiotics seem to regenerate heart cells in animals

Grace Wade

TWO widely used antibiotics may be able to regenerate heart cells in pigs, suggesting they might one day be used to treat heart failure.

Heart failure occurs when the heart can't pump enough blood to meet the body's needs. It often develops after heart attacks, which damage cardiac muscle. Other than an artificial heart or a heart transplant, treatments can only slow the condition's progression.

Now, Hesham Sadek at the University of Texas Southwestern Medical Center and his colleagues have used drug discovery software to screen already approved medications for the ability to bind to two proteins – Meis1 and Hoxb13 – that prevent heart muscle cells from dividing and regenerating. This helped the researchers identify two antibiotics that spurred rat heart muscle cells to divide in a dish: paromomycin and neomycin.

The researchers administered an intravenous infusion of both drugs to seven pigs with damaged hearts.

SHUTTERSTOCK/SEBASTIAN KAULITZKI

We might be able to use antibiotics to regenerate muscle cells in the heart

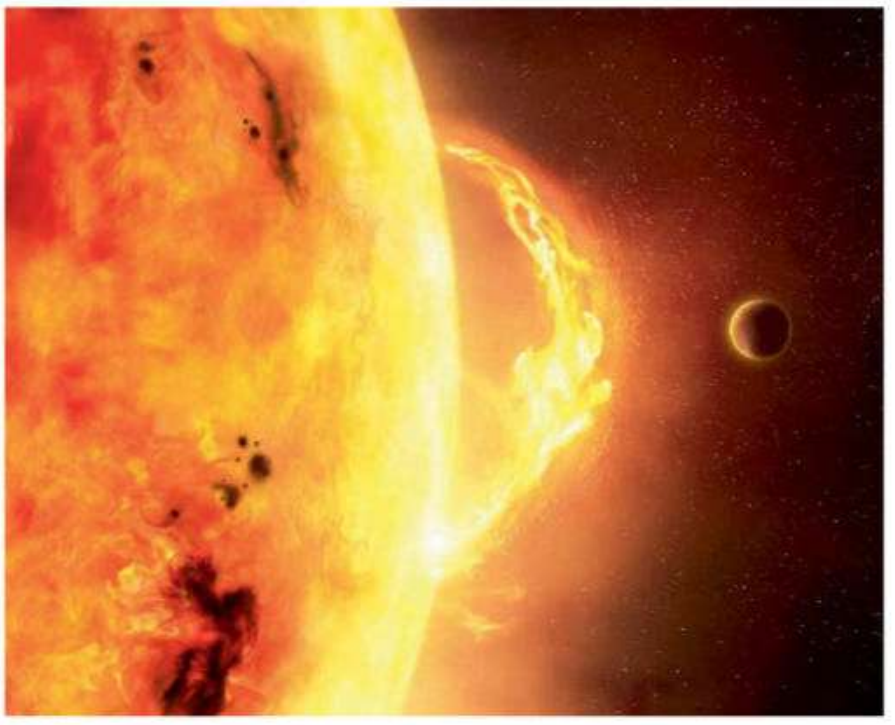
After five weeks, treated pigs' hearts had roughly half the amount of scar tissue as hearts from untreated animals with cardiac damage and were better at pumping blood (*Nature Cardiovascular Research*, doi.org/mm9z).

Hearts of treated pigs also had a roughly 25-fold increase in a biological marker of cell division compared with untreated pigs. The findings suggest that the antibiotic combination regenerates heart cells, says Sadek. ▮

Space

Largest recorded solar storm was even bigger than we thought

Alex Wilkins



JAMES THEW/ALAMY

Plasma from the sun can cause geomagnetic disruption on Earth

THE biggest recorded solar storm in history, the Carrington event of 1859, may have been even rarer and more extreme than we thought, according to rediscovered magnetic data gathered at the time.

In early September 1859, a massive solar flare was seen and a coronal mass ejection – a bubble of plasma and magnetic field expelled from the sun – struck Earth's atmosphere, triggering a geomagnetic storm that produced dazzling auroras and fried telegraph wires for days. If an event of similar magnitude happened today, it could cause havoc, knocking out satellites, communication systems and power grids.

Most of our knowledge of the Carrington event comes from contemporaneous descriptions from astronomers, including Englishman Richard Carrington, or magnetic recordings taken from an observatory in India. However, neither contains detailed numbers describing the storm's magnetic intensity, so it has been hard to know how strong the storm was compared with modern examples.

Now, Ciaran Beggan at the British Geological Survey and his colleagues have digitised paper recordings of Earth's magnetic field made throughout the Carrington event at two observatories in London, at Kew and Greenwich. They found that the intensity and speed of change in the magnetic field during the storm indicate it was at least a

1859

The year a solar ejection caused the huge Carrington event

1-in-100-year event, possibly as extreme as a 1-in-1000-year event (*Space Weather*, doi.org/mnfm).

This brings the storm more in line with some of the original estimates of its strength in an 1861 scientific paper, later revised down by physicists because they thought the original recordings were inaccurate. "Looking at the rate of change [of magnetic field intensity] just computed from the magnetograms, it's at least 500 nanotesla per minute, which kind of supports what the original 1861 papers suggested," says Beggan.

That is almost twice the expected size of a 100-year event, which would be about 350 nanotesla, he says.

To digitise the data, Beggan and his colleagues took images of the London magnetograms, which had been made using a magnetic needle suspended by a thread, the movement of which was recorded on paper to show the strength of the storm. They converted the millimetre deviations into a scale of standardised units. The needle goes off the chart for the peak of the storm, and some of the graphs are hard to read, so there is still some uncertainty over the storm's maximum strength, he says.

The researchers also found readings for an apparent geomagnetic storm several days before the Carrington storm, which may have contributed to the extreme nature of the latter. This is because the previous storm may have swept away some of the solar wind – the plasma of protons and electrons flowing out from the sun – leaving a clearer path for the Carrington storm, says Beggan.

"This is confirmation of how extreme the event was," says Ravindra Desai at the University of Warwick, UK. "People talk about the Carrington event being a 1-in-100 year event, but it's still just a bit wishy-washy. Having a published paper which quantitatively says this, is really, really valuable." ▮

Technology

AI boosts artists' popularity

People who used generative AI to create art got better feedback, despite it being less original

Chris Stokel-Walker

USING artificial intelligence to create artworks increases artists' productivity and generates more positive reactions, according to a study involving submissions to a popular art-sharing website by more than 50,000 users.

But generative AI works are more likely to display stereotypical themes and depictions, reducing the novelty of an artist's work.

Eric Zhou and Dokyun Lee at Boston University examined work posted on an art-sharing site between January 2022 and May 2023, a period that covered the release of the AI image generators Midjourney, DALL-E and Stable Diffusion.

The researchers tracked 4 million works published on the platform by 53,000 users. The people self-divided into those who continued to work using traditional methods – a sort of control group – and those who adopted AI. The latter, who numbered about 5800, were singled out by the use of tags on their work such as "AI-generated" or the names of the AI tools. Works posted into AI art communities on the site were also included.

Users who adopted AI tools saw their productivity – measured by the number of works posted – increase by 25 per cent over the study period. They also saw a 50 per cent rise in the number of "favourites" their work received over six months. But novelty, measured by the subject matter and specific details of the work, decreased for the AI-using group (*PNAS Nexus*, doi.org/gtk3dj).

"The productivity effects were to be expected," says Zhou. However, when it comes to the perceived value of such artwork as acceptable, he says, there are a lot of potential underlying factors.

He believes human artists using AI might have found a subculture within the platform that is accepting of this kind of work. "Or it could be that the quality of the artwork is potentially indiscernible from those of the traditional artists," he says.

Zhou declined to name the art-sharing platform from which the works were analysed, citing a non-disclosure agreement, but says it was a user-generated art website of a type similar to DeviantArt.

"At first, it felt that you could do anything, bring anything in your head into existence"

"The study completely tracks with my own experience with these tools and spaces," says Andres Guadamuz at the University of Sussex, UK. "At first, it felt that you could do anything, bring anything in your head into existence, but the more I used them, the more I kept coming back to themes I liked."

Guadamuz points out that he isn't judging the quality of the images produced by generative AI – nor their originality, nor the creativity involved in the process. All these things are often hotly contested, with some artists saying that generative AI is exploiting their works to use as training data and limiting their ability to be recognised as creatives. "I've been thinking about it more as exploration and not so much as creation," says Guadamuz. "You uncover a new image."

Zhou is also considering these questions. "Generative technologies are essentially giving everyone the same baseline skill," he says. "It accelerates the ability to produce. But it raises other issues: are we foregoing the process of understanding what goes into being creative and producing something meaningful, in favour of just being able to brute force our way with technology?" ▮

Animal behaviour

Blue tits shared a tree hollow with bird-eating bats

PREY animals usually prefer to stay out of reach of predators, but researchers have observed birds and bird-hunting bats residing in the same tree cavity in Italy.

Wildlife photographer Anne Mäenurm was monitoring greater noctules (*Nyctalus lasiopterus*), a species of carnivorous bat, in a forest near Udine as part of a study led by Danilo Russo at the University of Naples Federico II. One spring day, she saw a Eurasian blue tit (*Cyanistes caeruleus*) by an ash tree that bats used as a roosting site. The ash tree contained a vertical crack over 1 metre long. About 25 greater noctules resided in the cavity's upper section, while a nest of blue tits lay in the lower section (*Ecology and Evolution*, doi.org/mm93).

ANNE MAENURM

A blue tit and a greater noctule making their homes in the same tree cavity

"I was almost jumping from happiness," says Mäenurm. "What I had discovered was something unbelievable."

Mäenurm and her colleagues monitored the nest for a month and observed the blue tit parents bringing worms to the nest and, later, feeding two fledglings outside it. After some time, the birds were no longer present, suggesting that the chicks had fledged, she says.

The greater noctule usually feeds on insects in summer but preys on birds, including blue tits, when the birds are migrating.

Russo describes the bat as a fast flyer that is thought to capture birds mid-flight. However, some researchers believe that greater noctules capture birds in their nests.

"Our observation shows that when sharing the same cavity, the bats simply ignore the birds, and the birds seem not to be threatened by the bats," says Russo.

This coexistence suggests that these bats exclusively hunt birds in flight, he says. If the bats prey on flying birds, then they wouldn't perceive a nesting bird as a target, and the bird wouldn't perceive the predator's presence as a threat. ▮

Soumya Sagar

Archaeology

Britain's Pompeii revealed in detail

A settlement in the east of England burned down in a fire 3000 years ago, falling into a muddy waterway that preserved everything inside the houses, finds **Chen Ly**

THE remains of a Bronze Age settlement in eastern England have been exquisitely preserved after being destroyed by a fire 3000 years ago. An examination of the site gives an extraordinary snapshot of how Britons lived at the time, from what people may have eaten for breakfast to the tools they used to build houses.

Archaeologists first stumbled across ancient wooden posts at Must Farm quarry, near the small town of Whittlesey, in 1999. The small-scale investigations that followed sought to figure out whether there was anything interesting there, says Chris Wakefield at the University of York in the UK.

But it wasn't until 2015 that Wakefield and his colleagues, including researchers from the Cambridge Archaeological Unit and the University of Cambridge, conducted a full-scale excavation of the site.

The team uncovered the structural remains of four large roundhouses – circular dwellings

"Archaeologists talk of a Pompeii-like discovery, a moment frozen in time – this is one of those"

usually made of wood with thatched conical roofs – dating back to between 3000 and 2800 years ago.

Wooden stumps suggest these were built on stilts, connected by wooden walkways, over a small river that ran through the area. Based on the size of the channel, there may have been about 10 roundhouses at the settlement, says Wakefield.

Tree-ring analysis on wood from the structures suggests the settlement was destroyed a year after its construction, with the houses falling into the muddy

CAMBRIDGE ARCHAEOLOGICAL UNIT

The Bronze Age buildings at Must Farm were probably on stilts

water below. The waterlogged, oxygen-scarce environment prevented the settlement from degrading, preserving it in unprecedented detail, says Wakefield. Charring on the objects from the fire also provided a protective layer against environmental decay. "Pretty much everything that had been there at the time of the fire inside these people's houses has been preserved to find nearly 3000 years later," says Wakefield.

The way items fell into the mud gave clues to the layout of each house. As you step through the door, the kitchen area tended to be in the east side of the house, with a sleeping area in the north-west and pens for livestock in the south-east.

Chemical analysis of kitchenware, including pots, bowls, cups and jars, suggests that the settlement's prehistoric inhabitants probably ate porridge, cereals, honey and stews made with beef, mutton and fish (*Must Farm pile-dwelling settlement: Volume 1*, doi.org/mm9x).

"This is the best evidence we have on understanding prehistoric diet and cooking practices," says Rachel Pope at the University of Liverpool in the UK. "It's the closest we'll ever get to walking through the doorway of a roundhouse 3000 years ago and seeing what life was like inside."

CAMBRIDGE ARCHAEOLOGICAL UNIT

Burned wood is uncovered at the Must Farm site in the east of England. Other finds included pottery, clothes, decorative beads and tools

Once-in-a-generation site

Toolboxes filled with axes, sickles and razors were a staple in every household. "One of the most beautiful objects that one of my colleagues found was an incredible two-part hafted axe," says Wakefield. "What was so amazing about this particular design is that the axe head itself was inserted into an extra bit of wood that you could swap out."

The garments recovered at the site have a lush, velvety feel – they were made of some of the finest textiles produced in Europe at that time, says Wakefield. Decorative beads, which may have been used in necklaces, were also found across the site, possibly coming from elsewhere in Europe or the Middle East.

The settlement has been likened to the ancient Roman town of Pompeii, which was entombed in ash and pumice after a volcanic eruption in AD 79. "Archaeologists sometimes talk of a Pompeii-like discovery – a moment frozen in time – and this is one of those, a burnt-down settlement that gives us an intimate view into people's lives just before the fire and in the months running up to it around 2900 years ago," says Michael Parker Pearson at University College London.

"Must Farm is more than a once-in-a-generation site. It is very likely that there will never be a site that tells us more about Bronze Age Britain," says Richard Madgwick at Cardiff University, UK. ▮

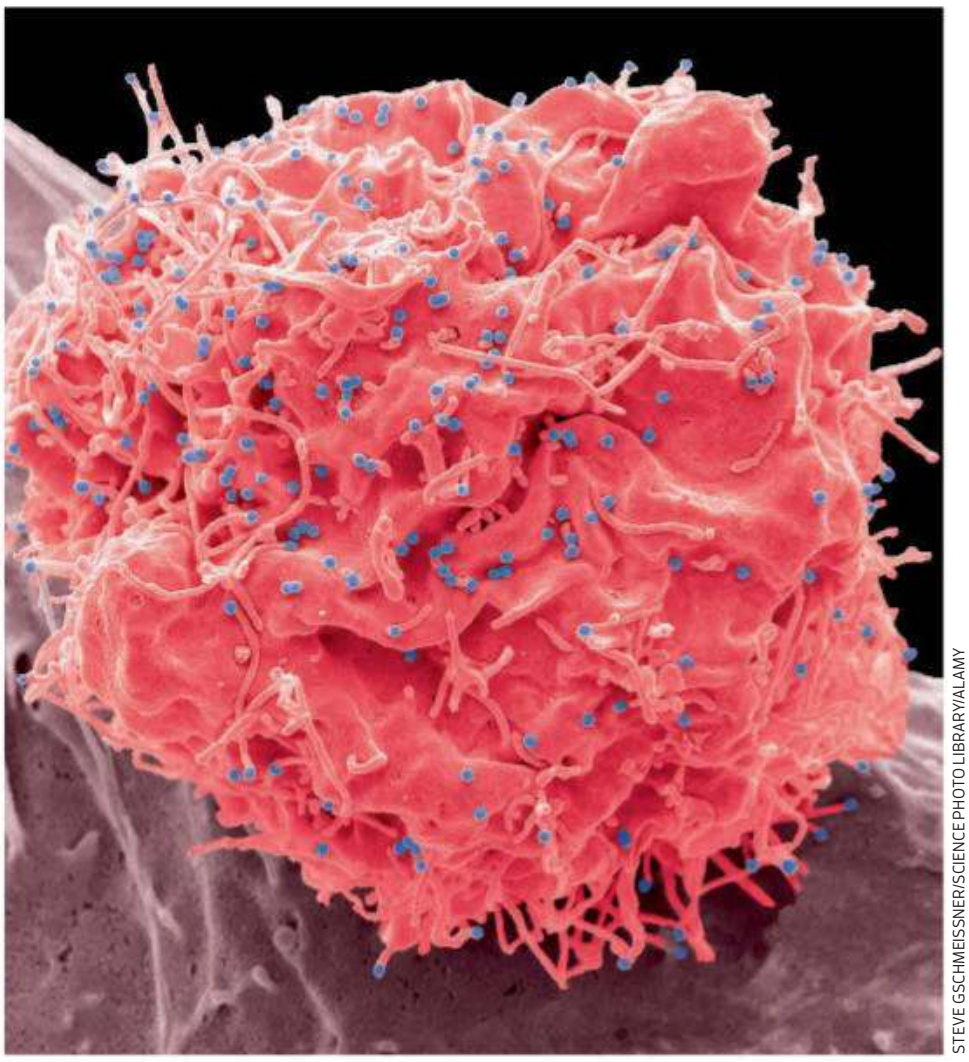
Technology

DeepMind AI advises on football tactics

AN ARTIFICIAL intelligence model can predict the outcome of corner kicks in football matches.

Petar Veličković at Google DeepMind and his colleagues developed the tool, called TacticAI, in collaboration with Liverpool Football Club. TacticAI was trained on data from 7176 corner kicks in the 2020 to 2021 Premier League season, including player positions over time and their height and weight. It learned to predict who would be the first to touch the ball after a kick was taken. In tests, the receiver of the ball was in TacticAI's top three candidates 78 per cent of the time (*Nature*, doi.org/mm95).

Coaches can use the AI to create tactics for attacking or defending corners that affect the chance of a certain player receiving the ball, and of a team being able to take a shot at goal. **Matthew Sparkes**



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY/ALAMY

Marine biology

Orcas get organised to hunt whale calves

ORCAS that live in the deep, open waters off the coast of California have specialised hunting tactics.

Josh McInnes at the University of British Columbia in Canada and his colleagues compiled observations of 183 orcas around Monterey Bay in California from between 2006 and 2021.

The killer whales seem to use underwater canyon walls for hunting, says McInnes. By patrolling these walls, the orcas can spot and chase mother whales until their calves get tired. Once the calves are separated from the mother, the orcas stop them from coming up for air.

In more exposed waters, groups of orcas tend to spread out and zigzag on long dives. Once an orca locates potential prey, it signals others in the area to come and hunt the prey together (*PLoS One*, doi.org/mnc3). **Chen Ly**

Health

CRISPR gene editing may be able to disable and cure HIV

A NEW way to eradicate HIV from the body could one day be turned into a cure for infection by the virus, hints a study with human cells.

The strategy uses a genetic method called CRISPR, making cuts in DNA to introduce errors into viral genetic material within immune cells. "These findings represent a pivotal advancement towards designing a cure strategy," researcher Elena Herrera Carrillo at the University of Amsterdam in the Netherlands said in a statement.

While infection with HIV was once nearly always fatal, people with the virus can now take drugs that stop it from reproducing. This gives them a nearly normal lifespan, so long as they take their medicines every day.

But when people are first infected, some of the virus inserts its DNA into their immune cells, where it stays dormant. If they stop taking their HIV medicines, this DNA "reawakens" and the virus starts spreading again.

For a cure, we need some way to kill any dormant virus in the body. Now, Carrillo and her colleagues have shown that, when tested on human immune cells in a dish, their CRISPR system can disable all of the virus, eliminating it from these cells. They are due to present the work at the European Congress of Clinical Microbiology and Infectious Diseases in Barcelona, Spain, in April.

Jonathan Stoye at the Francis Crick Institute in London says the results are encouraging, but the next step is trials in animals and eventually people to show that the treatment can reach all the immune cells with dormant HIV. Some of these cells are thought to reside in bone marrow, but there may be other body sites involved too, he says. Clare Wilson

Really brief

SHUTTERSTOCK/ARCTIC ICE

'Forever chemicals' lurk in food packets

Food packaging commonly contains up to 68 "forever chemicals" that carry possible health risks. These perfluoroalkyl and polyfluoroalkyl substances (PFAS) are long-lasting chemicals that are used to make goods like non-stick cookware (*Environmental Science & Technology*, doi.org/mnc6).

Drone with wheels can fly or roll along

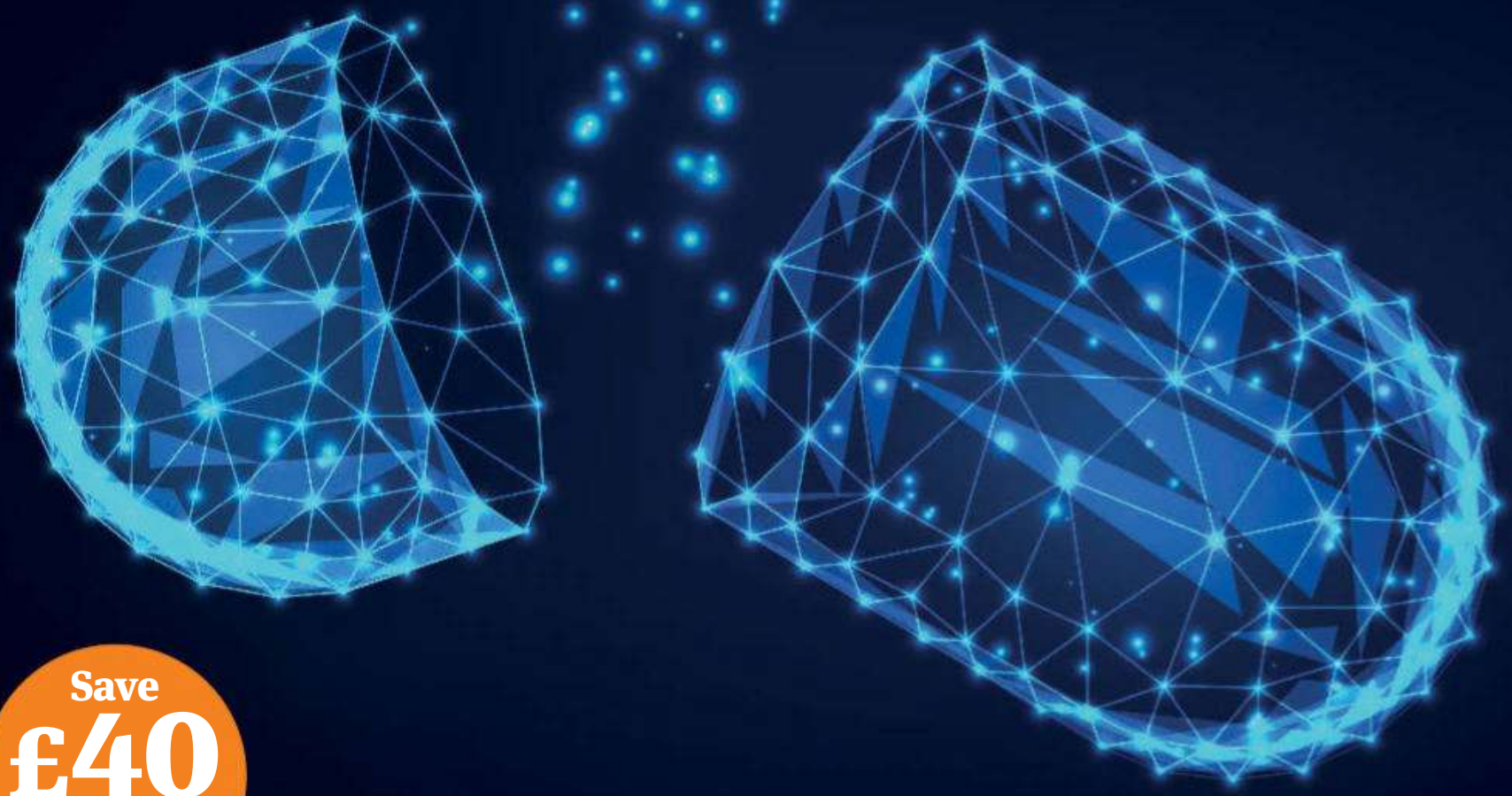
An autonomous drone with wheels can roll along the ground, only flying when it needs to clear obstacles, which helps its battery last seven times longer. The drone has four rotors along with two large, unpowered wheels. It can use thrust from the rotors to fly or traverse the ground (arXiv, doi.org/mnc9).

Billions of stars eat their planets

At least one star in every 12 seems to be a devourer of planets. Observations of 91 pairs of stars has revealed that about 8 per cent of the pairs contained one star that had devoured a planet and therefore had a higher abundance of heavy elements than its twin (*Nature*, doi.org/mndc).

Events

NewScientist



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Views

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Should we let some species die out, asks **Chris Simms** p22

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Simon Ings on Adam Sandler's trance-like film *Spaceman* p30

Comment

Surprise! It's a pulsar

Some of the greatest astronomical discoveries have come about by accident. We should embrace serendipity in science, says **Chris Lintott**

FOR a $10 billion instrument, the James Webb Space Telescope (JWST) spends a lot of its time staring at nothing. The shots of deep space this produces are remarkably beautiful, transforming an apparently empty sky into a field flecked with thousands of distant galaxies, some seen as they were just a few hundred million years after the big bang.

The first results of these surveys of the early universe have surprised astronomers, as the galaxies seem brighter than had been expected, with more star formation and larger black holes. Yet maybe we shouldn't have been too startled to find the universe surprising us: it has been doing so since we first peered into the cosmic darkness.

The most famous image of the early universe is the Hubble Deep Field, captured over a week or so in 1995. Yet this shot was almost never taken. Time on the Hubble Space Telescope (and on JWST) is precious and astronomers spend months preparing proposals to try to get even a few hours' worth of access. The process is a bit odd – often requiring researchers to argue simultaneously that the proposed observations would transform astronomy, but also that we know exactly what they will show – and competition is fierce.

There are normally seven or eight times as many proposals as can be accepted, so risky observations have trouble getting through. Back in the 1990s, many eminent astronomers argued that directing Hubble at deep space was pointless, betting that the space telescope wouldn't find a single new galaxy. This pessimistic outlook was based on assuming that the galaxies we see around us today are representative of those throughout the past 14 billion years or so, an idea we now know is badly wrong. The Hubble Deep Field was only rescued by the personal intervention of Robert Williams, then the director of the Space Telescope Science Institute, who used his personal access to Hubble to make it happen.

ELAINE KNOX

Finding the early universe lit up with firework displays of star formation was a serendipitous discovery. But once you start looking, you will find that astronomical history is filled with discoveries made by accident, or while scientists were looking for something else entirely.

When radio engineers first detected "star noise" coming f rom the cosmos in the 1930s and 1940s, they were ignored by astronomers who didn't understand the technology being used. Jocelyn Bell Burnell was supposed to be investigating the distance of what we now know are quasars when she spotted "scruff" in her data – the rapidly repeating signal that indicated the presence of the first pulsars to be detected.

The team behind NASA's Cassini probe was focused on its mission to explore Saturn's famous rings and its mysterious moon Titan when a chance encounter with the tiny moon Enceladus revealed fountains of water coming from its south pole. It is now perhaps the most likely place for us to find life beyond Earth. If aliens were to be found swimming under its icy surface, it would have profound implications across the cosmos.

These discoveries are all a long way from how science is taught, where careful experiment and testing of hypotheses lead to progress. Surprise is fun, so maybe we should embrace serendipity a little more. Several of the astronomers involved in sorting through this year's bumper crop of JWST observations have suggested it would be fairer, and easier, to allocate time on the telescope via a lottery, acknowledging that with so many good ideas floating around, we can't possibly choose between them. But whether it is staring into deep space or exploring the solar system, experience has taught us that preparing to be surprised by the universe is the best way to make new discoveries. ▮

Chris Lintott is professor of astrophysics at the University of Oxford and author of *Our Accidental Universe*

Wild wild life

Saving what we can Researchers are going to great lengths to protect northern white rhinos and bring back woolly mammoths, but is every species really necessary, asks **Chris Simms**

Chris Simms is an assistant news editor at *New Scientist*. He is interested in all things scientific, especially those related to biology, food, drink, history, politics and exercise. He is on X @chrisnsimms

Chris's week

What I'm reading
Down and Out in Paris and London *by George Orwell, again. It is a searing account of near destitution.*

What I'm watching
Mainly the menus of various streaming platforms as I scroll in vain for anything worth devoting time to. Any recommendations gratefully received.

What I'm working on
Finding the next fascinating news story.

Up next week:
Chanda Prescod-Weinstein

THERE are many organisms teetering on the brink of extinction. Take the planet's smallest marine mammals, vaquitas (*Phocoena sinus*), which are thought to now number fewer than 10 individuals in the Gulf of California. Or the last two remaining northern white rhinos (*Ceratotherium simum cottoni*) – both female – in Kenya. With no living males, odds of the species' recovery look slim.

These are just two examples; the IUCN Red List of Threatened Species lists 44,000 species that are at risk of extinction, more than 28 per cent of the species that have been assessed. We aren't going to be able to save them all. Indeed, it is widely accepted that species slip out of existence every day, perhaps dozens of them, most unnoticed.

With researchers going to great lengths to save northern white rhinos or even bring back woolly mammoths, the question arises: should there be a point at which we just let go and accept that some species can die out? And if so, how would we work out which species we could, with regret, wave goodbye to?

To get a better understanding of the issues involved, I talked to Rikki Gumbs at the Zoological Society of London's Evolutionarily Distinct and Globally Endangered (EDGE) species programme, set up to identify the organisms we could least afford to lose.

"We needed ways to prioritise the very limited resources," says Gumbs. "The idea was that we have these sets of species that might be critically endangered or endangered. How do we differentiate between them?"

Previously, conservation had prioritised species that are charismatic, he says. These include big cats, primates and other animals that look cute and have forward-facing eyes. "So EDGE was designed as an objective measure."

EDGE aims to protect some of the most extraordinary and rare species on the planet – those with few close relatives on the Tree of Life. These are often underdog species that look or behave in unusual ways. If one dies out, we are losing a species that represents a whole evolutionary lineage that might not be seen anywhere else on Earth, says Gumbs. Examples include the purple (or pig-nose) frog (*Nasikabatrachus sahyadrensis*), which, with its rounded, flattened body, looks a little like a tiny, shiny elephant that has been squashed. Or the Mary river turtle (*Elusor macrurus*), which can stay submerged for 72 hours by breathing through glands in its reproductive organs and often has a mohawk-like shock of green algae growing on its head.

"Conservation has, in the past, prioritised species that are charismatic, like big cats, primates and cute animals"

Choosing to save species with no close relatives means you are safeguarding gene combinations not found in other organisms. Preservation of natural wonder aside, maintaining this broader amount of genetic diversity also ensures we preserve a wider array of the benefits that humans get from other species.

But what about the other end of the spectrum? Are there less-special species we can afford to let go? Although you might have found some ecologists who backed that idea a few decades ago, none seems willing to voice that opinion now.

This is because of something called extinction debt. It might seem OK to lose a species here or there, because knock-on effects might not be seen immediately. But that is because there is a time lag between initial losses and the subsequent disappearance of more species. For example, research in 2022 looked at the reduction of forest cover caused by the second industrial revolution in the mid-19th century, and saw its influence in the extinction patterns of reptiles, amphibians and mammals today.

The bottom line is that even if some species might not seem as important or as cute or as special as a panda, a tiger or a turtle with a shock of green hair, we can ill afford to let any more of them die out. And, as Gumbs says: "We are driving so many species extinct. I think it's valiant that we make the effort to put things right where we've caused the problems, no matter how vain. It seems if we were to give up on the vaquita, I would feel like, what's the point in me going to work tomorrow?"

All this makes me wonder whether we should even try to make tough choices on which organisms should live or die. Over evolutionary time periods, the arrival of new species has involved the natural extinction of others that were no longer as suited to a changing world, but it is hard to argue that the current level of extinction is natural. Some 44,000 species are on the brink because we have fundamentally altered the world by cutting down trees, eroding soil, damming rivers, burning fossil fuels, extracting water and much more. The responsibility on us shouldn't be to choose from what is left, but to right our wrongs and save as much as we possibly can. ▮

Perpetual lunacy

The extraordinary new **C1 Moonphase** from Christopher Ward. A watch that tracks the moon for 128 years – without missing a beat. With an aventurine glass dial infused with copper oxide to represent the night sky. And a 3D 'moon' sculpted from Globolight© – a luminous ceramic – that precisely follows the real moon's journey across the sky. A watch this advanced can cost up to £45,000. But the C1 Moonphase starts from less than £2,000. As someone once said, you don't have to be mad to work here...

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Christopher Ward

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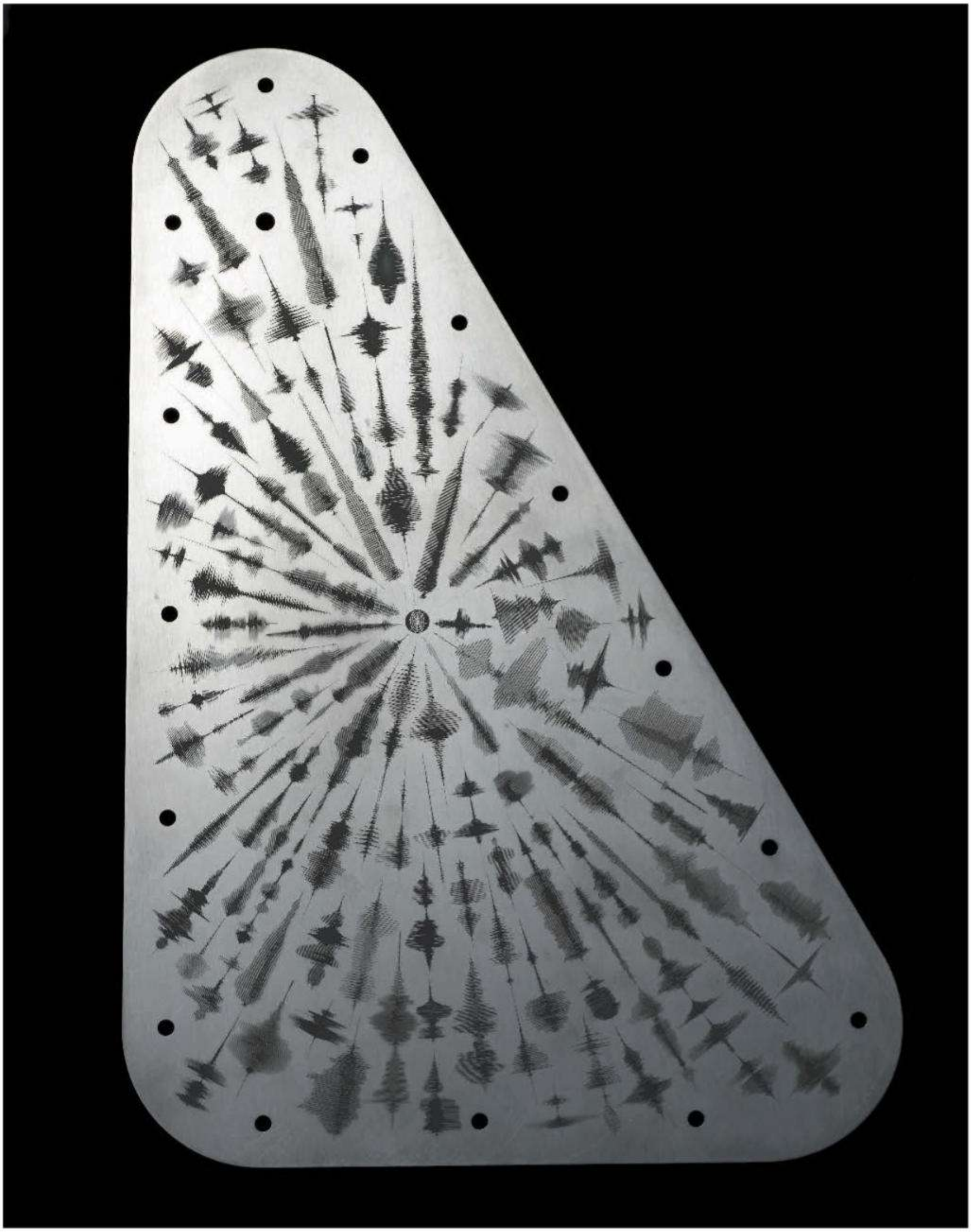

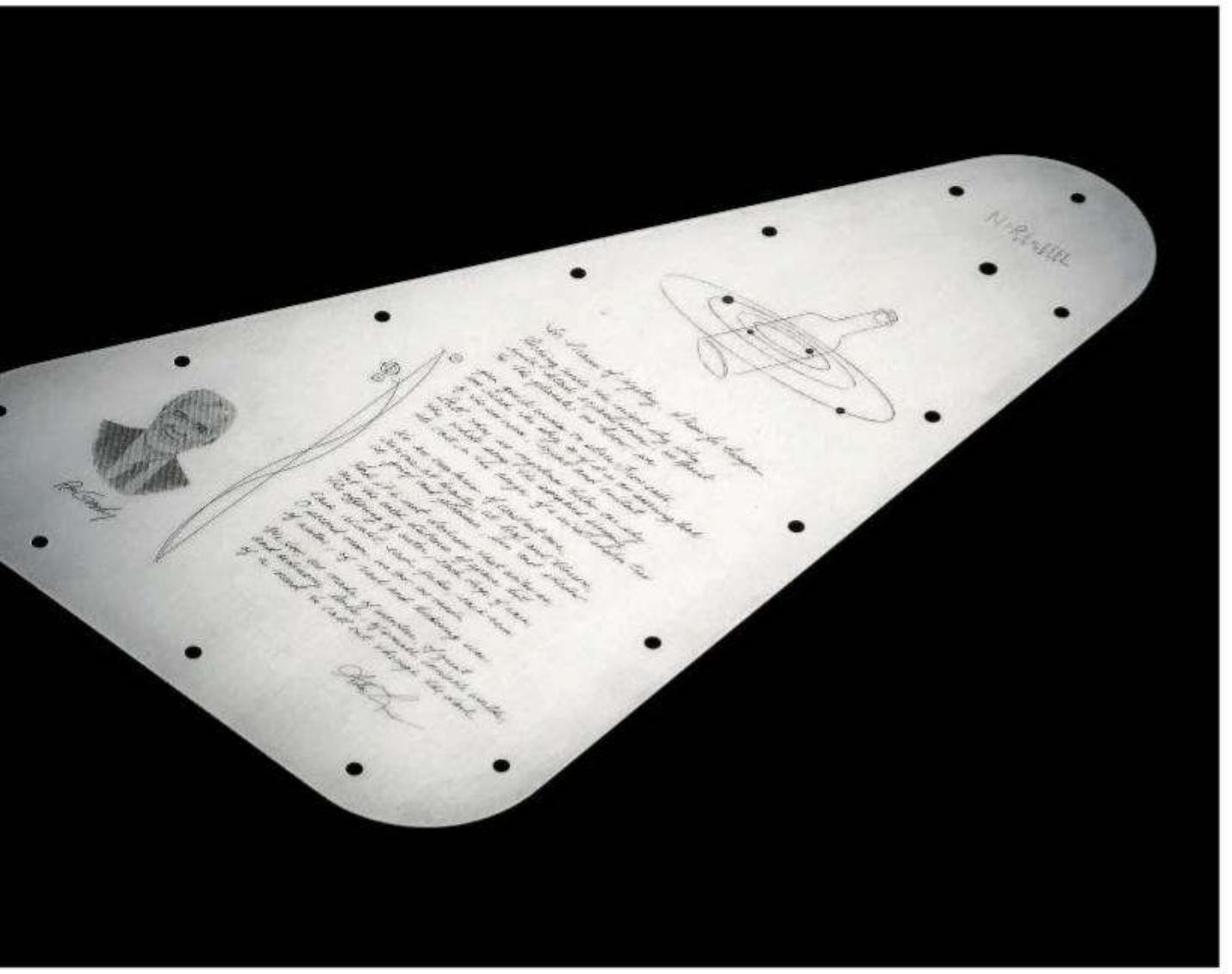

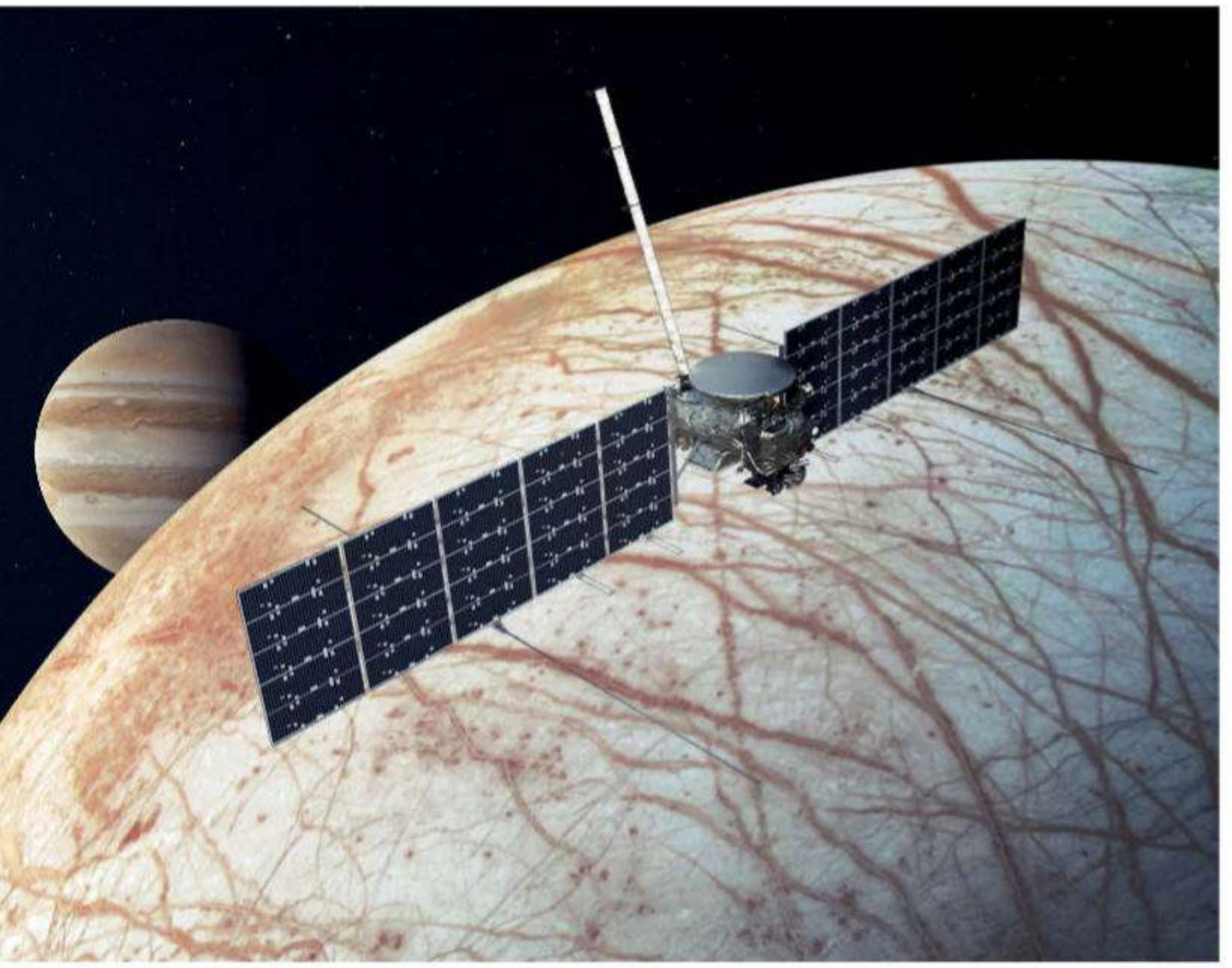

O second moon

NASA/JPL-Caltech

IN OCTOBER, NASA's Europa Clipper spacecraft is due to start its journey to explore Jupiter's ice-encrusted moon Europa (imagined here in illustration).

NASA asked the scientific organisation that I lead, METI International, to draw on our expertise at attempting to contact extraterrestrial intelligence and help craft a symbolic missive engraved on a tantalum plate attached to the spacecraft – greetings from one water world to another.

We helped create two parts of the message. First, we collected a globally representative sample of audio recordings of the word for water in 103 languages, showing each as a waveform on the outward-facing side of the panel (shown at far left) that protects sensitive scientific instruments.

On the other, inward-facing side (near left, at top), we designed the scientific part of the message. This describes water in terms of the "water hole", the band of frequencies between the hydrogen and hydroxyl (which combine to form water) emission lines in the radio spectrum where many early searches for intelligence beyond Earth were conducted.

Other parts of the interior message include: the Drake equation, which estimates the number of extraterrestrial civilisations in our galaxy; a microchip with the names of 2.6 million endorsers, to be added closer to launch; and US poet laureate Ada Limón's poem to Europa, which ends: "O second moon, we, too, are made / of water, of vast and beckoning seas… / of a need to call out through the dark." The Europa Clipper is due to enter Jupiter's orbit in April 2030.

Douglas Vakoch, president of METI International

Editor's pick

Thinking about machine empathy

9 March, p 32

From Peter Thomson, Paris, France

Amanda Ruggeri reports that many researchers question whether artificial intelligences can have empathy, even in principle. And if one were to produce something that looks like empathy, some think that wouldn't be real. But isn't this the same assumption about human uniqueness that can be applied to machine intelligence? The Turing test – in which a machine tries to pass as a person – wasn't designed as an actual assessment, but as a thought experiment to undermine the assumption that a machine couldn't be intelligent. Surely it also works in relation to empathy. After all, we don't really know what is going on in an empathising brain. Couldn't it be something rather like a large language model?

From Paul Whiteley, Bittaford, Devon, UK

Many years ago, I wondered if there was any aspect of the human condition without a downside. I thought I had a winner in empathy. Then it became apparent that, for con artists, empathy is their most important weapon. This trait is the most powerful tool humans have. It therefore becomes our greatest exploitable weakness. Empathy-enabled AIs could be more dangerous than guns, knives or charismatic political and religious leaders. Handle with care!

From Tim Stevenson, Prestwood, Buckinghamshire, UK

We have no solid basis for the common assumption that other people are conscious, let alone that a therapist feels with us and isn't merely emulating empathy.

From David Bortin, Whittier, California, US

Ruggeri clearly and correctly characterises empathy as "Ugh, I know exactly how you feel". She goes on to say that "ultimately, you can't really know what sadness is unless you have felt sad". There is the rub: a truly empathetic therapist, friend or confidant needs to have really been there. Where? Where no AI has ever been.

Early concern over sports concussion was ignored

9 March, p 36

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Graham Lawton's welcome piece on sports-related concussion recalled for me my earliest days in the UK's National Health Service. In the early 1960s, I began working for a consultant physician who had a much-articulated hobbyhorse concerning brain injury, with particular reference to boxing and to football heading. He advocated as widely as he was able the need for changes in both sports, to outlaw heading the ball and to make blows to the head in boxing as unlawful as blows below the belt. Needless to say, his efforts of more than six decades ago went largely unheeded. He used to illustrate his point by saying: "If you fill a tin bucket with eggs, and then set about belting the bucket with a lump hammer, you would be a fool not to expect a few of the eggs to crack, at the very least."

From Jim McHardy, Clydebank, Dunbartonshire, UK

Anyone who has looked at the paths of seismic waves from an earthquake will have seen the waves refracted by the increasing densities of the crust, mantle and core. Multiple reflections back and forth are seen to occur, during which the waves repeatedly hit Earth's surface. In various places inside Earth, these waves come to a focus where they cross over.

This raises the question of what happens in the brain when someone is struck on the head. Assuming a similar mechanism, even a small bump could cause some damage by displacing brain tissue where waves focus. This has obvious repercussions for any contact sport.

Still in harmony with Pythagorean music

9 March, p 15

From Guy Cox, Sydney, Australia

In defence of Pythagoras, that he showed us music was based on harmonic intervals was a very impressive analysis with the primitive tools at his disposal. What is more, some of nature's most wonderful singers, the Australian pied and grey butcherbirds, create beautiful melodies based on those intervals, and these can be transcribed using Western musical notation.

That isn't to suggest that non-Pythagorean intervals can't be enjoyable. There are examples in Western music: Scottish bagpipes aren't tuned to the conventional scale. But Pythagoras laid the groundwork, and butcherbirds prove him right. They have been around longer than him.

Getting habituated to the dire state of the world

2 March, p 40

From Sam Edge, Ringwood, Hampshire, UK

I liked your interview with Tali Sharot on habituation and found a lot of sense in it. In particular, it reminded me of how the endless stream of charity adverts on TV, many of which are repeated in graphic detail ad nauseam during the daytime to get repeat payments from senior citizens, can only have the effect of numbing us to the injustices they are trying to address.

Why can't water firms remove microplastics?

9 March, p 19

From Barry Cash, Bristol, UK

You report that boiling tap water can remove microplastics. But this only really works for hard water, as the microplastics co-precipitate with the calcium carbonate. In which case, you must also avoid using the water in the very bottom of the kettle. I think I would prefer a water company to supply water without microplastics.

One size won't fit all for long covid treatment

17 February, p 14

From Katherine Langford, Moorland, Somerset, UK

I feel a significant flaw in research on the use of exercise for post-viral conditions such as long covid is that many people aren't well enough to participate. I have moderate ME and yet wouldn't be able to take part in an exercise programme like the one in the article. Unfortunately, this can lead to a self-selecting sample of those who are moderately to mildly affected by such an illness. Findings can't be generalised to those who are severely ill.

In some places, staking might be right for a tree

20 January, p 44

From Bill Parslow, Brighton, UK

Just following up on James Wong's look at the science of staking trees, one of the ever-present hazards for plants in urban environments is being knocked into, bashed and generally destroyed by passers-by, council mowers and the like. Might it be that tree staking succeeds in these environments purely by putting a physical barrier around the young plant? ▮

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Pub cellar spotted doing 56mph down the M1

Don't be alarmed, it's just one of our lorries. Good beer needs to travel well, so to ensure our beer is delivered to pubs in perfect condition we designed our own special delivery lorries. These 'cellars on wheels' keep our casks at between 10 and 12 degrees, the same temperature as a pub cellar. Meaning whatever the weather and whatever the distance, our beer can begin the vital cask conditioning that gives it that delicately balanced flavour and crisp, clean finish. So however far you are from our brewery, you know you're always going to get *that taste of Taylor's*.

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Going cosmic

An insider account of particle physics takes us to the heart of the action through an engaging, accessible and fun read, says **Anna Demming**

Book
Space Oddities
Harry Cliff
Picador

A BALLOON the size of a football stadium hovering over an Antarctic ice sheet. A Zoom screen of researchers awaiting a big reveal. A lone researcher caught up in covid-19 restrictions, holding a slip of folded paper up to a webcam...

The vivid opening sequences of *Space Oddities: The mysterious anomalies challenging our understanding of the universe* give glimpses into what proves to be a cracking tale of particle physics and cosmology. The author is Harry Cliff, a particle physicist, writer and former science comic.

His book is structured like a film script, where each subplot is prompted by an anomaly in physics – the kind of thing that has experts muttering what Cliff calls science's most auspicious phrase: "Hmm, that's funny..." A growing number of these anomalies are cropping up. These, he says, can herald "breakthroughs" or "lead science astray... ruining careers".

In cosmology, the big worry is the divergence of the two ways of measuring the Hubble constant. Measuring this more precisely is one of the field's great missions because it tells us the rate at which the universe is expanding and helps unravel the history of the universe and predict its fate. If the methods don't agree, writes Cliff, it implies "our basic model... is wrong".

A similar fear haunts particle physics. We know our grasp of reality's fundamental particles and forces in the standard model of particle physics is incomplete. It was hoped the Large Hadron Collider (LHC), a huge accelerator at CERN, the particle physics lab near Geneva, Switzerland, would fill in the gaps. But not much has happened since the discovery of the Higgs boson in 2012.

The book explains this through a diverse, international cast, spanning Japan to Trinidad, with several women in lead roles. None of this seems forced. They just happen to be the best researchers for that part of the story.

Another key ingredient is Cliff's colourful language: the weak nuclear force is described as so "pifflingly feeble" that neutrinos pass through rock

"The book is structured like a film script, where each subplot is prompted by an anomaly in physics"

"without exchanging so much as a flirtatious wink with an atom". His metaphors can be violent, the big bang "a lacerating, annihilating growth, one that destroys, tears, and rends". The general use of such metaphors was questioned earlier this year in an op-ed in *Scientific American*, and while these days you might ask if it is really apt for Cliff to describe black holes as "terrifying", for example, here the language mostly works effectively to amp up the drama.

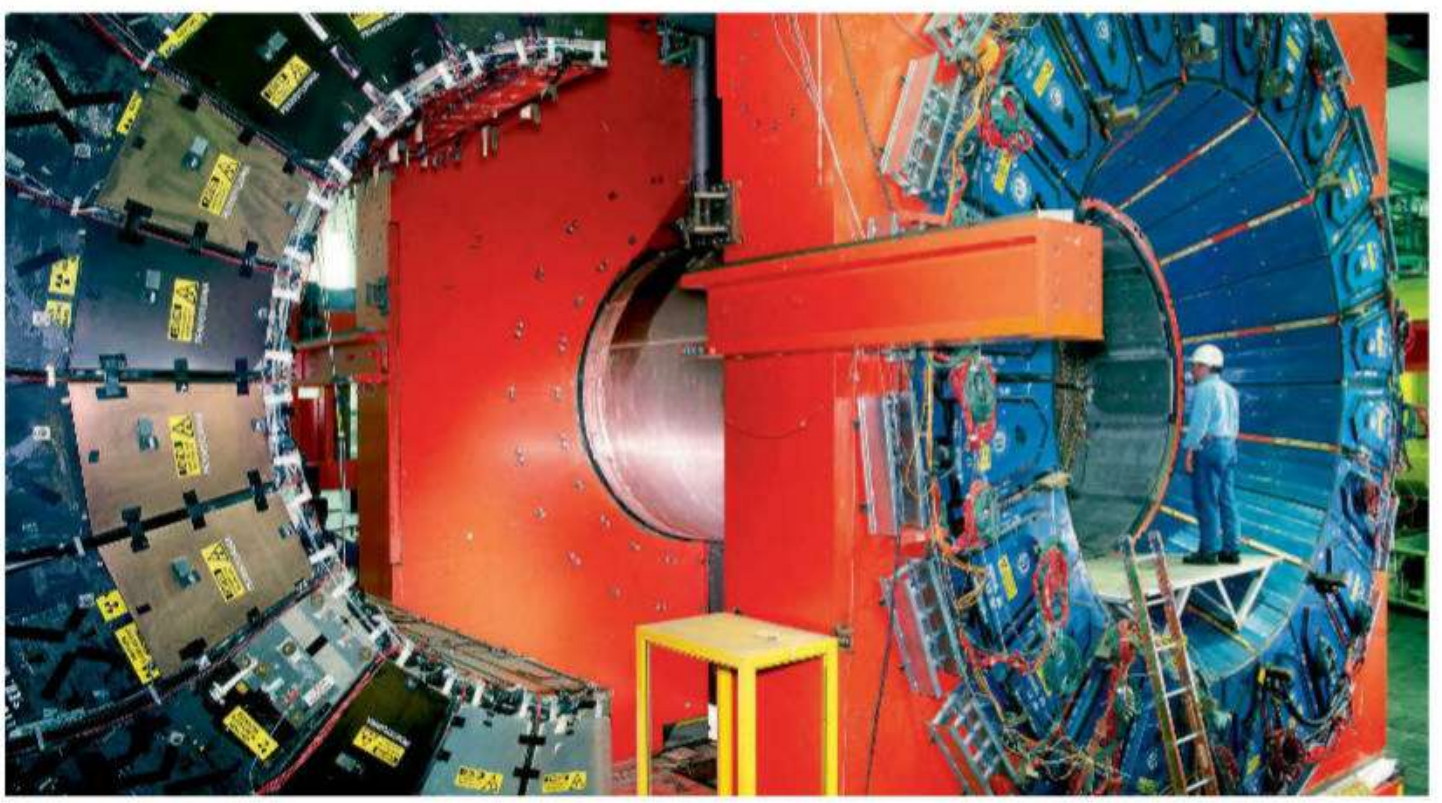
Cliff also deftly handles the language of previous eras, now a little hard to swallow. For example, he acknowledges that Victorian phrases such as the "subjugation of new regions" haven't aged well. This was used by James Clerk Maxwell in an 1871 lecture to set out his vision for the future Cavendish Laboratory, in Cambridge, UK.

Maxwell, who helped lay the foundations in theoretical physics, argued in favour of redefining the boundaries of what we understand rather than endorsing the limited view of the times, that the greatest discoveries had been made. As a particle physicist analysing data from the LHC, Cliff would also have every reason to fight against a dead end. His access takes the reader to the centre of the action. The description of his own project is nail-biting, and the intimacy it affords not only makes this a compelling book, but opens a window into science and what makes the problems it tackles both so hard and irresistible. Projects like the LHC are hugely expensive and funded by taxpayers, but provide stories to attract a new generation of researchers.

It also means we are in expert hands for the technical side of the story. Alongside much else, we learn about "sigma values" (used in statistics to measure uncertainty, or, here, anomalies). Why not stop tutting about how late the bus is and assess the evidence that it is likely to be late again tomorrow (in excess of 5 sigma, since you ask: time to walk).

Overall, *Space Oddities* is a rare joy – enlightening, thrilling and inspiring.

Anna Demming is a writer based in Bristol, UK



The Collider Detector at Fermilab in Illinois, setting up for more discoveries

DAVID PARKER / SCIENCE PHOTO LIBRARY

New Scientist video
See clips of the AI-enhanced dance show *A Body for Harnasie* at **youtube.com/newscientist**

First and last strike

What exactly would happen in a nuclear attack on the US? **George Bass** explores an all-too-plausible account

Book
Nuclear War: A scenario
Annie Jacobsen
Torva

OLIVIER DOULIERY/POOL VIA CNP/DPA/ALAMY

IN 1985, US President Ronald Reagan and USSR President Mikhail Gorbachev declared in a joint statement that "a nuclear war cannot be won and must never be fought". A year later, the number of atomic weapons globally began to fall from a peak of nearly 70,000. By 1989, the cold war was ending, and the world rejoiced at being less likely to die in a flash of light at 100 million °C – more than six times hotter than the centre of the sun.

Reporter Annie Jacobsen was nominated for a Pulitzer prize in 2016 and has written for the *Jack Ryan* TV series. Her extraordinary book *Nuclear War: A scenario* reminds us the nuclear nightmare never really ended, it just shifted from a duel to a Mexican standoff. She has consulted scientists, soldiers, emergency management experts and presidential advisors to imagine a scenario in which one of the world's eight other nuclear powers attacks the US.

Her book delivers more detail than has been available to the public before. She even managed to get the Los Alamos National Laboratory in New Mexico to declassify the origins of the "football". This is a suitcase carried by a military aide who accompanies the US president at all times, containing the emergency action documents needed for them to initiate a nuclear strike.

We are taken minute by minute through the flight of an intercontinental ballistic missile as it journeys towards the US, carrying three nuclear warheads – a fraction of the total held by the US and Russia. When it strikes, millions are killed, buildings are vaporised, animals are burned alive in zoos and the first mushroom cloud is uploaded to social media.

A suitcase, nicknamed the "football", contains the launch codes for a US nuclear strike

But posting very quickly becomes a thing of the past as more bombs cut electricity. "The electromagnetic pulse of the bomb obliterates all radio, internet, and CCTV," notes Jacobsen, an unsparing narrator. Panic, paranoia, comms breakdown and the failure of countermeasures (only ever tested in simulation) soon bring in other nations. Each is poised for a "decapitation strike", where a country targets its enemy's nuclear arsenal and the officials with the power to authorise action.

The speed at which Jacobsen's conflict escalates explains why the Doomsday Clock, which shows how close we are to catastrophe, was set at an unprecedented 90 seconds to midnight in January 2023.

Despite talks and promises of disarmament, Jacobsen outlines how the modern world is no more stable than during the days of the so-called Iron Curtain. Nuclear submarines roam international waters, with the USS Nebraska alone capable of "unleashing twenty times more destruction than all the explosives used in World War II, including both atomic bombs dropped on Japan", she writes.

As well as graphic descriptions of what nuclear winds do to humans, Jacobsen describes the "nuclear winter" in detail. This is forecast to happen when 150 teragrams (150 million tonnes) of soot is lifted into the upper troposphere by the blast. Survivors will subsist under a sky thick with cyanides and vinyl chlorides from burning buildings. The attack's radiation will decay, but take about 24,000 years to do so.

At the outset of her terrifying account, Jacobsen reveals that the US's Single Integrated Operational Plan – a first-strike system active from 1961 until 2003 against the USSR, China and Soviet-aligned states – wasn't hampered by the potential retaliatory attacks that would kill an estimated 100 million US citizens and many more millions in China, Russia and other countries.

After the cold war drama, Jacobsen leaves us with an opinion of her own: "Nuclear war is insane. Every person I interviewed for this book knows this."

George Bass is a writer based in Kent, UK

New Scientist *recommends*

David Stock
Head of editorial video
London

Contemporary dance, artificial intelligence, orchestral music, Polish folklore – that's **A Body for Harnasie** (pictured),

a heady mix from the mind of choreographer Wayne McGregor, working with visual artist Ben Cullen Williams.

I saw this version of Karol Szymanowski's ballet score at London's Southbank Centre. The event brought together the London Philharmonic Orchestra with AI-enhanced footage of dancers, projected onto a shape-shifting sculpture (see link above).

I also got a peek at **Autobiography v95** by McGregor, which uses Google's AI tool AISOMA (trained on his archive) to create new movements for this exploration of the self through dance.

Another treat will be at the Royal Geographical Society, London, from 7 May. **Everest 24** is a photographic exhibition to mark the 100th anniversary of the 1924 British Mount Everest expedition, with images from the archive. The trek, meant to be the first to summit Everest, failed and four of the team died.

RAVI DEEPRES & LUKE UNSWORTH

The film column

Out there *Spaceman* stars Adam Sandler as an astronaut who looks like he is losing his grip. But the opposite is closer to the truth in a movie with many virtues, transcendental aspirations and a rather overblown conceit, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

LARRY HORRICKS/NETFLIX

Jakub (Adam Sandler) must come to terms with the nature of his reality

CZECH astronaut Jakub Procházka (Adam Sandler) is dying of loneliness, six months into a solo space mission to visit a mysterious purple cloud. His wife Lenka (Carey Mulligan) is pregnant and, being already a lot lonelier than Jakub (who has been a wholly unsupportive husband), she decides to leave him.

Mission controllers keep the news from Jakub, but he knows what is going on. It is his sense of despair that draws in help from beyond in the shape of a telepathic spider who can pass through walls but is otherwise as real and solid as anything on Jakub's spaceship (a sort of inside-out junkyard full of believably outdated but serviceable machinery, ducts, keyboards, lights and a toilet pump that won't stop screaming).

Spaceman is directed by singer-songwriter turned film-maker, Johan Renck, now better known for the docudrama *Chernobyl,* for which he won a best director Emmy. It is an assured, deliberate experiment in pacing that will frustrate many, not least because it is delivered at a single, trance-like speed. While this is entirely right for a story that appears to be about a man losing his grip, the plot is, in fact, rather the reverse. Jakub must come to terms with what reality actually turns out to be – extraterrestrial clouds, telepathic spiders and all. "The universe," his strange companion

"It is Jakub's sense of despair that draws in help from beyond – in the shape of a telepathic spider"

assures him, even as they both face extinction, "is as it should be." And here's the kicker: the spider is right.

Spaceman is monotonous only in the sense that time itself is monotonous, and the film's transcendental aspirations are well served by Hans Zimmer's shimmering, shuddering score. This is more sound art than music, and easily as powerful as anything he wrote for Denis Villeneuve's *Dune* films – which is saying a lot.

Since playing the lead in the crime movie *Uncut Gems*, Sandler the serious actor has little left to prove. Here, he embodies Jakub's terror, melancholy, anger and self-hatred with absolute commitment and truthfulness – five years ago, who would have bet "egoless" and "Adam Sandler" could ever appear in the same sentence?

Paul Dano voices Jakub's arachnid companion with a poetic pathos that would be cloying in a more regular movie, but it works superbly well here, almost as if his every word were a prayer. Yet in its effort to be spiritual – more mass than movie – *Spaceman* simplifies the already fairly simple plot of its source material, Jaroslav Kalfař's novel *The Spaceman of Bohemia*. This is a mistake.

Jakub is lonely. So is his wife. She leaves him. Counselled by his spider friend, Jakub gets in touch with her (a neat trick, using a goofy, faster-than-light phone called CzechConnect and a purple fragment from the beginning of the universe). They speak, and Jakub begins his long return.

At which point, I woke from my trance and thought, why does the story of a man trying to make up with his wife six months into a work assignment require a space mission, a strange cloud, quantum telephony and a telepathic spider?

Spaceman has many virtues, but when you come down to it, the film is about someone trying to fix his work-life balance, and doing so in the most expensive, portentous manner imaginable. He's lonely? Boohoo. She's leaving him halfway into a solo flight? That's a lousy, selfish thing to do. Bang their heads together, I say, to hell with the limitations of space-time!

And this, just to spoil it, is pretty much what happens. ▮

Film
Spaceman
Johan Renck
Netflix

Simon also recommends...

Film
Dark Star
John Carpenter
On demand
John Carpenter's student film, co-written with Dan O'Bannon (who later wrote Alien*), makes comedy out of the far reaches of the void.*

Book
The Black Corridor
Michael Moorcock
Gollancz
Tough-minded British businessman Ryan is on his way to Barnard's Star to restart humanity after the collapse of civilisation on Earth. Or so he thinks...

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TONI DEMURO

The power of one

For decades, we have assumed that spending time alone is a bad thing. Yet solitude can help us to flourish, says **Heather Hansen**

RECENTLY, I was walking alone on a quiet, winding trail. The path was hard to follow and slick with snow. The sun felt warm on my face. As I trudged uphill, I missed my partner, but felt grateful to be visiting my sister who I don't see often.

I was on my own for a couple of hours that day. During that time, I felt wide-ranging emotions, including curiosity, anxiety and joy. It was a welcome period of solitude and I returned to civilisation feeling calmer and more clear-headed than when I had set out.

Think about the last time you were alone. Maybe you were commuting to work or had woken up before the rest of your household. Perhaps you live alone. Did you revel in that period of solitude, long to connect with another person or let it pass by without much thought?

Solitude is inevitable. Adults in the UK and US spend around one-third of their waking lives alone and that increases as we get older. In many places, we live alone in greater proportions than ever before. A recent survey of 75 countries shows that 17 of them have more than 25 per cent solo households.

As social creatures, research has historically pointed us away from time alone. But recently, more people are spending time away from the crowd, and even seem to crave it. Now, we have evidence as to why alone time can feel so good and may in fact be vital to your health and well-being. Moreover, we have discovered the best ways to be alone – learn these secrets and you could grasp the real power of solitude.

Researchers have been cataloguing the negative aspects of feeling alone, including loneliness, social isolation, anxiety and ostracism, for over a century. From that body of work, we know that isolation – which is often wrongly conflated with solitude – is harmful. We see this clearly in studies of the solitary confinement of prisoners, which show that being alone in these conditions increases the long-term risk of cardiovascular disease and mental health problems.

Recently, though, researchers have begun to re-examine time spent alone in less extreme circumstances. In *Solitude: The science and power of being alone*, a book I co-wrote with researchers Netta Weinstein at the University of Reading and Thuy-vy Nguyen at Durham University, both in the UK, we set out to understand how everyday solitude affects people's lives. Together, we wanted to know whether these moments are beneficial, and possibly essential to living a balanced, happy life.

> "It doesn't matter what you do during your time alone as much as how and why you are doing it"

In the largest study of its kind, thousands of participants from the UK aged between 13 and 85 told us their solitude stories through online surveys. From that data, we were able to more clearly define solitude and its requirements, then begin to sort out who feels good in solitude and why.

In that and other studies we ran, we learned that everyone has a unique definition of what solitude looks like in their lives, but there are commonalities across age, ethnicity and gender.

For some participants, the word "solitude" conjured visions of a monk in a mountaintop monastery or a determined hiker alone in the wilderness. Most people described less lofty but equally consequential experiences of solitude achieved while, for example, cooking a meal, walking in a park or writing in a journal.

Surprisingly, our participants described solitude as having a psychological distance from others, but not necessarily a physical one. That means they could be sitting in a room with a trusted loved one or even on a city bus and still reap some benefits of time alone – as long as they could truly have independent thoughts. Being free of others' expectations and input is one aspect of solitude that makes it so relaxing for many people.

In several separate experiments, Nguyen and her colleagues focused on some of these apparent stress-busting effects of solitude. They found that when people spend 15 minutes alone, there is a "deactivation effect", meaning "high arousal" emotions (both positive and negative) like excitement and anxiety are decreased, while positive "low arousal" feelings like calmness are increased. This wasn't seen when people spent 15 minutes with another person. ›

One caveat is that sometimes solitude also increases the negative low arousal feeling of loneliness. However, a further experiment showed that this increase in loneliness could be diminished when individuals chose to think about positive thoughts or when they were given a choice whether to spend time alone. The researchers also found that when participants partook in 15 minutes of solitude each day for a week, the beneficial effects on stress spilled over into the following week.

Together, these studies indicated to us that, done correctly, people can use solitude to regulate their underlying emotions. A small amount of solitude allowed them to become quiet after excitement, calm after being angry, or peaceful when they desired.

The list of benefits doesn't end there, though. Through our own work and that of others, Weinstein, Nguyen and I have seen that alone time can foster well-being through self-discovery and feelings of inner peace, competence and self-reliance. Early research suggests that it may even enhance creativity – although this depends on exactly why a person is withdrawing from society. Several studies link time alone and creativity, but only when people avoided social interactions by choice, because of what is known as a "non-fearful" preference for solitude. It is thought that anxiety-free time spent in solitude may allow for and foster creative thinking. On the other hand, there was no such link in those who withdrew because of shyness, in which a fear or anxiety prevented them from interacting with others, or because of avoidance, where people disliked social interactions.

> "Time spent in solitude can enhance creativity – but only when you avoid social interactions by choice"

Fundamental needs

Our own experiments hint that chosen solitude may even fulfil some of the same needs as our social relationships do. This gels with some of Weinstein's latest research, carried out with Mark Adams, also at the University of Reading, which shows that solitude contributes to a feeling of emotional well-being by nurturing three fundamental needs: feeling connected to others, feeling competent and feeling that you have autonomy. While those needs are generally experienced during social interactions, Weinstein and Adams's work suggests that solitude can also help achieve something similar.

"We saw that on days when people spent more time alone, they got more of that sense of, 'Yeah, I can be myself today, I have a say in what happens, I can do things that matter to me and that I choose, and I feel less pressure'," says Weinstein. Notably, the researchers also found that even in the absence of social interaction, individuals still experienced a meaningful sense of connection to others.

Of course, some people can feel loneliness as a consequence of being alone. Glance at the news nowadays and you will see headlines reporting a "loneliness epidemic". However, most of the time, loneliness is erroneously linked with solitude. The confusion is easy to understand, says Weinstein. After all, "loneliness and solitude share a word in most of the world's languages, so in those cases, we can't talk about them as separate", she says. "But when we conflate the two, we not only do injustice to solitude, but also to loneliness."

Scientists tend to define loneliness as a hurtful discrepancy between what we want from social relationships and what we are actually getting. That means we can be lonely in a stadium filled with people or while sitting next to a partner if we don't feel connected to them. It is also common. "To be human in the modern world is to feel occasional bursts of loneliness," says Eric Klinenberg at New York University, who researches living alone and social isolation.

Feeling lonely from time to time is evolutionary and adaptive. It is a cognitive alarm reminding us to connect to others for the sake of survival. Nowadays, we don't need our neighbour's help to catch dinner or ward off a predator, yet our brain still signals that we do. That kind of transient loneliness is benign, but if it becomes chronic, loneliness can have severe consequences. A recent analysis of 90 studies looking at more than 2 million adults aged 18 years or older linked chronic loneliness with a 14 per cent higher risk of dying early and social isolation with a 32 per cent increase.

Late last year, the World Health Organization launched a Commission on Social Connection to "address loneliness as a pressing health threat". That came on the heels of an advisory issued by the US surgeon general, Vivek Murthy. The 82-page document, Our Epidemic of Loneliness and Isolation, calls attention to the "public health crisis of loneliness, isolation and lack of connection" in the US.

However, a major problem with such advisories is that most of our existing evidence base is skewed by studies that conflate subjective loneliness with objective measures such as living alone. "When we [conflate

RAGHU RAI/MAGNUM PHOTOS

Psychological distance is possible, even in a crowd

LOLOSTOCK/ALAMY

Withdrawing into solitude can help you regulate emotions

"Spending more than 75 per cent of your time alone is associated with greater loneliness"

solitude and loneliness], what are we not seeing and what kinds of opportunities are we missing out on?" says Weinstein. "That's where the research on solitude is really helpful."

Ideally, there would be a formula for how much time humans need to spend with and without others to maximise our chances of health and happiness. But emerging research indicates there is probably no one-size-fits-all answer.

A recent study by Weinstein, Nguyen and their colleagues explored the link between daily solitude and social time, finding no optimal balance. People were lonelier and less satisfied on days when they spent more hours in solitude, but it didn't accumulate across days – those who were generally alone more weren't, on average, lonelier. And this link reduced or disappeared entirely when the participants' solitude was chosen. On days when people chose to spend more time alone, they also felt less stressed and had greater autonomy. These benefits were cumulative: individuals who spent more time alone across the three weeks studied were less stressed and more satisfied overall. "There's no single answer for what is the 'right' amount of socialising or solitude, it'll be different for each of us," says Weinstein.

However, while there may not be a magic number, one recent study of 438 adults aged between 24 and 90 indicates that there may be a tipping point for when alone time shifts to loneliness. Spending more than 75 per cent of your time alone was associated with greater loneliness.

On the other end of the spectrum is "aloneliness", a term coined by Robert Coplan at Carleton University in Ottawa, Canada, and his colleagues to describe the feeling solitude-seekers have when thwarted from time alone. "I was very surprised that there wasn't a word that reflected the experience of feeling cranky, grumpy, upset or having other negative emotions as a function of feeling like you were not getting enough time alone," he says. (Coplan is currently floating terms amongst his peers for someone who enjoys being alone – so far, "soloist" is in the lead.)

Solitude siren

Some people may hear an aloneliness siren similar to the evolutionary loneliness alarm, but may not know what it means, says Virginia Thomas, a psychologist at Middlebury College in Vermont. "One of the skills I teach is to listen to your own internal signals saying you need to be alone." When you can't think straight or feel depleted, those are signs you are overstimulated. "An antidote to this is to withdraw into solitude as a way to get regulated again," says Thomas. Once someone lands on the right mix for them, they then "have to work strategically to get that balance met", she says.

So far, we have learned that being alone tends to be positive, as long as you have chosen to do so, are motivated to be alone and have balanced that time with social interactions. But once you have scheduled some time for solitude, what should you do while you are there? Do you need to zone out watching Netflix or go for a hike?

The simple answer is that it doesn't matter what you do as much as how and why you are doing it. In studies, people experienced the deactivation effect even while reading a book alone. Similar results were seen in an experiment by Dwight Tse at the University of Strathclyde in Glasgow, UK, and his colleagues. In their study, 283 participants were randomly alerted via an app six or seven times a day, at which point they answered a short survey about their momentary thoughts, feelings and behaviour. Tse's team found that what you do in moments of solitude doesn't matter so much as having choice over the activity. Chosen activities had little effect on the benefits of solitude, whereas unchosen solitary activities appeared relatively harmful to the person's well-being.

If you aren't sure what works best for you, you could try using a technique that Weinstein calls "crafting solitude". This is an intervention that she and Adams outlined in a recent paper. It is designed to mould an individual's relationship with solitude by challenging negative assumptions and guiding them through meaningful solitary activities. Across two studies, this type of guided solitude resulted in less stress and anxiety in participants and more relaxation compared with a group who hadn't used the technique. "Engaging in solitude as a place where opportunities can be pursued benefited their sense of well-being," says Weinstein.

Ultimately, though, you may still dislike being alone. But if you weren't "born to solitude", we have a secret weapon for you: curiosity. We have found from our research that individuals who approach solitude with a curiosity as to what being alone might help them achieve were able to alleviate any discomfort they felt during difficult moments of solitude.

Now think about the next time you will be on your own. Will you revel, suffer or fail to notice it? As evidence mounts for how time alone can be a positive force in shaping our lives, my colleagues and I recommend planning for it – and protecting it. ▮

Heather Hansen is a journalist and author based in Boulder, Colorado

Grow slow

Human childhood is uniquely protracted. How did it evolve to be that way and why, wonders **Michael Marshall**

I WAS going to start this article another way. But that was before my 10-year-old daughter intervened. In fact, I had already begun writing when she bounced up and tried to scam me. She offered to bet me £10 that she could make an ordinary pencil write in the colour red. Alas for the budding entrepreneur, I refused the bet: she was too confident, so I suspected she had something up her sleeve. But I did let her reveal her trick. She took a lead pencil and wrote "in the colour red". Then she laughed like a hyena and went off to try scamming her mother.

Our bright little spark has opinions about everything from video games and sports to books. She is learning basic algebra and coding, and her Taylor Swift expertise vastly outstrips mine. Yet, despite all this knowledge, she has years to go before adulthood. If she lives an average lifespan, a quarter of her years will be spent underage.

The long human childhood is a real oddity. No other primate spends so much time becoming an adult. Over the course of our species' evolution, along with more obvious physical changes, childhoods got vastly longer. Traditionally, palaeoanthropologists have paid little attention to children, but now that is changing. A spate of intriguing discoveries in the past few years is building a picture about human childhood: when this seemingly unproductive life stage expanded, why it is so long and what prehistoric kids got up to. The findings don't just throw light on a dark corner of human evolution, they also reveal why childhood is so important.

Childhood is surprisingly difficult to define. "It's so basic and hard at the same time," says April Nowell at the University of Victoria in Canada, author of *Growing Up in the Ice Age*. Western societies often use a straightforward chronological measure: we may become legal adults on our 18th birthday, for example. But that is far from a universal concept. "In a lot of societies, they make that transition between child and adult based on whether someone has certain skills or a certain personality or certain abilities," says Nowell.

Defining childhood by biological markers of growth is problematic too. For instance, most of us are sexually mature long before 18, yet we keep developing long after that. "Our skeletons finally finish off at about 25," says Brenna Hassett at the University of Central Lancashire, UK. Besides, as well as physical development, childhood is also, crucially, a time of mental development,

RENE BERNAL/UNSPLASH

of learning and play. And, at its most basic, it is when we are dependent on adults to provide food and other necessities. "For me, childhood is a period when other people are investing in you," says Hassett.

Why the long phase?

However you measure it, though, the length of human childhood is exceptional – even compared with that of our closest relatives, the great apes, which all have long childhoods too. Hassett compares us to bowhead whales, which only hit sexual maturity when they are about 25 years old. However, they often live for over 200 years, whereas humans rarely reach 100. "We're spending a quarter of our time as juveniles," says Hassett. As a proportion of a lifespan, that is inordinately long.

And it isn't just a matter of length. Human childhood is also qualitatively different. Primatologists think of monkeys and apes as going through three stages: infant, juvenile and adult, with infants spending most of their time clinging to their mothers and juveniles moving around more freely. In contrast, humans have five stages, says Nowell: infant, child, juvenile, adolescent and adult. "Childhood and adolescence are two new phases of the human life history that are inserted into this more typical primate pattern," she says. The child phase lasts from weaning until the eruption of the first permanent molar tooth (between the ages of about 2 and 6). Adolescents are physically able to reproduce, but are still maturing in both body and mind. Although there is now evidence suggesting that, like us, chimpanzees experience an adolescent growth spurt, nevertheless, human life history has clearly been radically reshaped. When did this happen?

The story of human evolution spans some 7 million years. Unfortunately, the oldest hominins are only known from a handful of fossils, so we have little or no information about their childhoods. "It's a spotty fossil record," says Philipp Gunz at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. Only with *Australopithecus*, which lived in Africa between about 4 million and 2 million years ago, do we start to have enough specimens to say something meaningful. In a 2020 study, Gunz and his colleagues scanned the skulls of eight *Australopithecus afarensis* from ›

DANITA DELIMONT/ALAMY

Turkana Boy's growth pattern indicates that childhood was already getting longer 1.6 million years ago

over 3 million years ago. They found that youngsters had smaller brains than modern chimpanzees of the same age, while the brains of adults were a bit larger than those of adult chimps. "This can only be if they grow their brain for a longer period of time," says Gunz. So it looks like childhood was already lengthening somewhat over 3 million years ago.

Our own genus, *Homo*, emerged between 3 million and 2 million years ago. Compared with earlier hominins, the first *Homo* had significantly bigger brains and were committed to walking upright. They made and used stone tools and ate a broader diet, including meat. But did they also have longer childhoods than earlier hominins?

There is still some debate, but the clearest evidence comes from a *Homo erectus* youngster from near Lake Turkana in Kenya. Turkana Boy, also known as Nariokotome Boy, lived about 1.6 million years ago. He seems to have been about 8 years old when he died. His brain indicates a faster growth rate than that of modern humans, says Hassett, "but it's on a different trajectory from the earlier australopithecines". And the implications of that are clear. "By the time you get to *H. erectus*, around 2 million years ago, there's a significant extension of childhood," says Nowell. What's more, childhood growth patterns hint that the child and adolescent phases had emerged.

Our own species, *Homo sapiens*, evolved around 300,000 years ago. We follow the same five-stage pattern as earlier *Homo*, but "even more slowed down, even more elongated", says Nowell. This lengthening of childhood may have evolved gradually over millions of years, or there may have been rapid spurts followed by periods of stasis, says Gunz. Without many more fossils, there is no way to tell. Nevertheless, we can ask why it happened.

One much-discussed idea centres on the difficulty of human childbirth. Compared with other apes, human labour is extremely painful and dangerous. This has been attributed to our bipedal stance, which led to our hips becoming narrower, together with the evolution of bigger brains. Put simply, we are pushing a large object through a small hole. In 2022, Tesla Monson at Western Washington University in Washington state and her colleagues showed that pregnancy began changing as early as 6 million years ago. "Infants kept growing larger and larger, and their brains got larger along with them," says Monson. As a result, human babies must be born when they are still underdeveloped and helpless. "We always talk about the first year after birth as being almost a second gestation," says Nowell.

Prehistoric childhood

Nevertheless, this alone can't explain the evolution of longer childhoods. Once babies are born, they are free to grow, so, in theory, could develop rapidly to adulthood. But they don't. This means we need to look beyond childbirth to prehistoric children: how they lived and what they were doing. Until the past few years, archaeologists have neglected to do this. Indeed, they often regarded children as a nuisance who made a mess of important artefacts by playing with them. "We weren't thinking about the lives of those children," says Nowell. That is now changing. And as our picture of prehistoric childhood expands, so too does our understanding of why this stage of life is so important.

Take this charming tableau. In Bàsura cave in Italy, footprints and other traces reveal what looks for all the world like a family outing 14,000 years ago. There were five people: a man and a woman, a teenager and two children, the youngest about 3 years old. They walked barefoot, using burning sticks to light the way, and went deep into the cave. At one point, the youngsters seem to have collected mud from the floor and smeared it onto a stalagmite. "Maybe it was a rainy day in the Palaeolithic and they went exploring," says Nowell.

Perhaps these children were also displaying a creative urge – because we know that even very young kids were involved in making art. A 2022 study looked at hand stencils painted on cave walls in Stone Age Europe. Some were so small

Palaeo-parenting today

Humans have been parenting for a very long time. So can we learn anything from prehistoric parents about how to raise our children?

"The internet and the world are full of people telling you how to palaeo-parent," says Brenna Hassett at the University of Central Lancashire, UK, author of *Growing Up Human*. There are messages about the ideal way to carry a baby, how much freedom to give your kids and what to feed them – all extrapolated from archaeological studies. But these studies were never intended as parenting advice, says Hassett.

The reality, she says, is that humans are defined by an immense adaptability. What was sensible parenting 100,000 years ago when we were all hunter-gatherers isn't necessarily sensible in an agricultural society with a global internet and a disinformation problem.

"My message would be: just stop freaking out about how your kids are sleeping or being carried," says Hassett. "There is no one true evolutionary way. We are continually changing."

DON HITCHCOCK (2014)

A carved bone disc (above) and owl-like plaque (below) seem to be prehistoric toys

that they must have been made by infants, with help. Prehistoric art probably had meaning for the people who created it, but sometimes it could have been made just for fun. And there is plenty of other archaeological evidence that fun and games have long been a part of childhood.

At Laugerie-Basse in France, for example, archaeologists found a bone disc dating from between 11,000 and 18,000 years ago. On either side is a picture of a deer in a different pose, and there is a hole in the middle through which string could be threaded. Nowell and her colleagues point out that if the string were twisted and released, the disc would spin, creating the illusion of the deer moving, like a child's flip book. Owl-like plaques from Bronze Age Spain may also have been children's toys. Most early toys were probably made of perishable materials like wood, so have rotted away. But other forms of play can still be seen. At Le Rozel in France, there are footprints of Neanderthal children running around, as if playing a chase game like tag.

Decades of research leaves no doubt that play has a serious purpose – it is a way of learning new physical, psychological and social skills. And in prehistory, it may have had an additional role that made it even more crucial for our ancestors. The appearance of certain toys in the archaeological record coincides with technological innovations, such as the wheel and weaving, hinting that child's play inspired some key human inventions.

Prehistoric children also needed to learn skills for survival. A study published in 2022 looked at young foragers in 28 modern societies and found that, while children easily learn to collect fruit and shellfish, the exploitation of resources such as tubers and

"Children would have been a key demographic in ensuring the survival of their communities"

ISABEL MARÍA VILLANUEVA/JUAN JOSÉ NEGRO

game isn't mastered until adolescence or adulthood. This, the researchers concluded, supports the idea that a long childhood evolved as a period in which to learn complex foraging skills. So too does evidence of tool-making at Stone Age sites where artefacts created by expert flint-knappers are mixed with amateurish efforts – suggesting children were trying their hand at it.

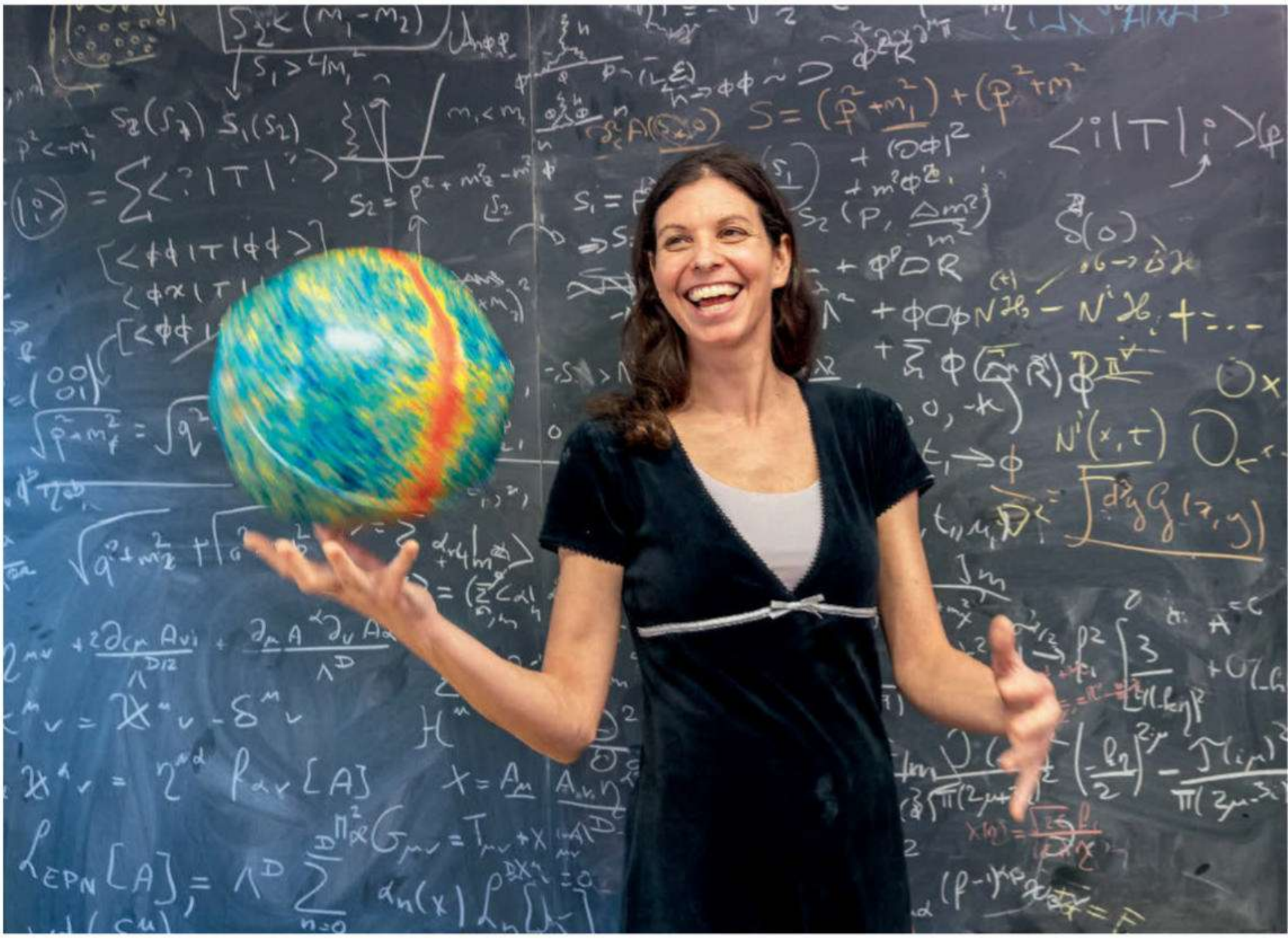
The overall picture is that prehistoric children had rich and complex lives, filled with different activities, and were always learning and exploring: "learning about how to navigate complex social situations, alongside basic skills acquisition and everything that makes us able to operate as humans in this world", says Monson.

This long phase of learning has obvious benefits for children. Intriguingly, it may also shape the societies in which they live. "As children grow, who they choose to learn from changes," says Nowell. In hunter-gatherer societies, children start by learning from their parents, but as they enter adolescence, they start to seek out other adults – especially those they perceive as innovative. Teenagers may thus be a linchpin in the spread of innovations. "Not all knowledge is carried from one generation to the next," she says. "I think that children and teens are particularly important in deciding what they carry forward."

In fact, youngsters probably played an even bigger role in prehistory, because there were so many of them. A 2008 review suggested that kids made up between 40 and 65 per cent of the population, a far higher proportion than now. "Children would have been a key demographic in ensuring the survival of the overall community," says Nowell.

It is tempting to wonder whether modern parents can learn anything from our forebears (see "Palaeo-parenting today", left). But Nowell believes that the recent research holds a subtler lesson. "It changes how we see children and their contributions to their communities," she says. There has been a popular notion that children are just empty vessels that we must fill with knowledge. This is flat out wrong, she argues. "Children have always had agency. Children have always made important contributions to the overall well-being of their communities. And they have a role in shaping where our societies are going in the future." ▮

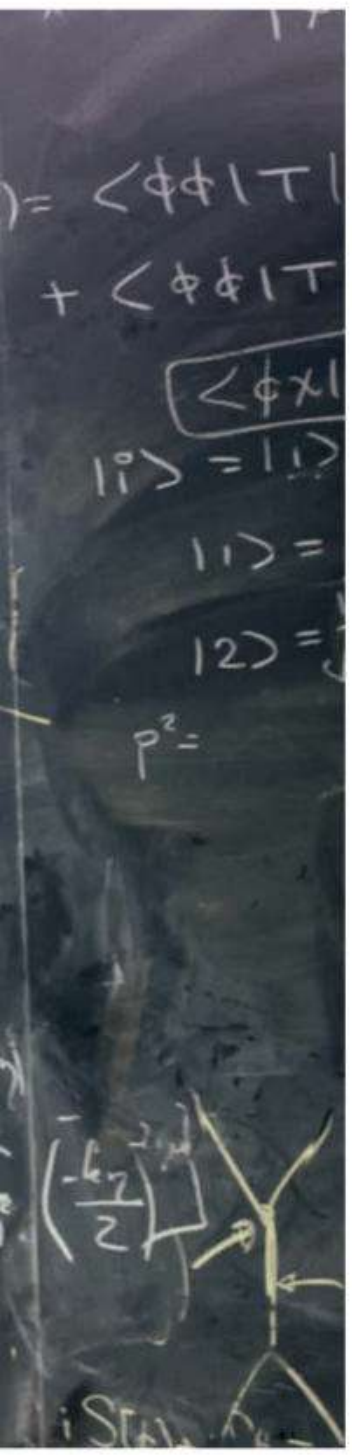
Michael Marshall is a freelance writer based in Devon, UK



DAVID STOCK

Falling for gravity

Claudia de Rham has spent much of her life exploring the universe's most enigmatic force. **Joshua Howgego** takes her indoor skydiving to get a flavour of what she has discovered



THE fans roar into life, pumping air upwards at 260 kilometres per hour. Decked out in a baggy blue jumpsuit, red helmet and plastic goggles, Claudia de Rham steps forward into a glass chamber and... whoosh! Suddenly she is suspended in mid-air, a wide grin on her face, thrilling to the simulated experience of free fall.

I had persuaded de Rham, a theoretical physicist at Imperial College London, to come indoor skydiving with me at iFLY London. It seemed fitting, given that much of her life has been dedicated to exploring the limits and true nature of gravity – and launching ourselves out of a plane wasn't an option, at least on this occasion.

As she describes in her new book, *The Beauty of Falling*, de Rham trained to be a pilot and then an astronaut, only for a medical problem to scupper her chances of the ultimate escape from gravity. But she has gone on to explore this most familiar and mysterious force in a more profound way, as a theorist, and made an impression by asking a radical question: what does gravity weigh?

By that she means the graviton, the hypothetical particle thought to carry this force. If it has mass, as de Rham suspects, that would open a new window onto gravity. Among other things, we might finally spot a "gravitational rainbow" that would betray the existence of gravitons – and with them, a long-sought quantum description of gravity.

As de Rham floats on air, she makes it look easy. She is soon ascending to the top of the chamber, some 10 metres up. "That was incredible, really fun," she says, as she emerges, giving high fives to the instructors. "What you feel is not really gravity," she explains. "It's the pressure of the air. But it's fascinating how you can play in there, by balancing the pressure of the air and gravity itself."

After we both get our feet back on the ground, de Rham tells me that she has always been drawn to the force that keeps them there and orchestrates the motion of planets and galaxies throughout the universe. It started at the age of just 5, while living in Iquitos in the Peruvian Amazon. She remembers swinging in a hammock there and noting the feeling of weightlessness for the first time. "As I gazed up at the stars... I could almost imagine floating in outer space, out of time and conquering gravity," she writes in her book. "This moment sparked what would become a lifelong fascination with the subject."

As a child, de Rham moved frequently from country to country with her parents, who worked in sustainable development. Thinking about something so universal as gravity was strangely comforting amid all the upheaval, she says. "There was a sense of stability that came from being part of something much bigger than me."

Aspiring astronaut

Later, while studying for a PhD in Canada, she trained as a pilot and went on to apply to be an astronaut with the European Space Agency. She made it through several rounds of screening, one of which involved a simulated rescue mission through a mock jungle. Of more than 8000 candidates, she got down to the last 42. But then a battery of medical tests revealed that she had a latent tuberculosis ›

"It is a radical question: what does gravity weigh?"

“The equations of gravity are very pure, almost transcending any form of communication”

NASA, ESA, CSA, STScI, J. Lee (STScI), T. Williams (Oxford), PHANGS team

The spiral galaxy NGC 1566 was sculpted by gravity

infection, meaning she was disqualified.

Thankfully, de Rham had also been working towards another way to conquer gravity – not by escaping its clutches in planes or rockets, but by trying to figure out how it works at the most fundamental level.

She was drawn to study gravity by its simplicity. When it comes to describing its workings at cosmological scales, she says, you have to remove all complications. “I mean, it is a little hard to believe when you first look at the equations. But for me, they are very pure, and they almost transcend any form of communication.”

The equations to which she is referring are those of Albert Einstein’s general theory of relativity, which describes gravity as the result of mass warping space-time. At the heart of the theory is the equivalence principle, which essentially says that you can’t distinguish gravity from acceleration. More specifically, it posits that an object’s resistance to acceleration and the gravitational force it experiences are both proportional to its mass. It is an odd coincidence, but one that has always been borne out in experiments. Together with the constancy of the speed of light, it underpins our current understanding of gravity.

You can think of this equivalence as Einstein did in a famous thought experiment. Imagine being in an elevator in space, accelerating “upwards”. Inside the elevator, you would feel a force pinning you to the floor, but it would be impossible to tell if this was the normal effect of Earth’s gravity or if you were in space, but accelerating. Indeed, part of the fun of indoor skydiving was to conjure something roughly akin to this thought experiment. When I shut my eyes in the cylinder, with the air rushing past my ears, it is indistinguishable from the free fall of real skydiving.

Elusive particle

Today, gravity, as described by general relativity, is one of the four known fundamental forces of nature. Yet it is the outlier. The other three forces are described within quantum theory, meaning that they come in discrete chunks. For the majority of physicists, gravity should fit the same mould. But we still don’t have proof of that, never mind a quantum description of gravity.

For her part, de Rham has sought to make progress by thinking deeply about gravitons, the hypothetical carrier of the force of gravity. Each of the fundamental forces is carried by an equivalent “boson” particle – some have zero mass, others have a very small mass. De Rham wanted to know: what is the graviton’s mass?

She wasn’t the first to ask that question. In previous explorations of the idea, any attempt to give gravitons mass meant that they would come in a variety of forms, one of which would have negative energy. Since that seemed physically impossible, the idea of gravitons with mass, known as massive gravity, fell by the wayside. But de Rham felt there was more to it. Working with her husband Andrew Tolley, also a physicist at Imperial College, and Gregory Gabadadze at New York University, she was able to work out a consistent new framework for massive gravity that doesn’t spit out negative

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energy particles. This was the first time anyone had produced a workable framework in which gravitons could have mass. In 2020, she won a Blavatnik award for "developing an innovative mathematical framework that yields a rigorous and viable theory of massive gravity" and "profoundly impacting our understanding of many fundamental problems in cosmology and particle physics".

One of the biggest problems remaining is whether gravity really does come in the form of gravitons. Even if these particles exist and have mass, it would be vanishingly small, which makes snaring them hugely challenging. Still, one way to find out involves gravitational waves, the "ripples in space-time" first observed using the Laser Interferometer Gravitational-Wave Observatory (LIGO) in 2015. This detection wasn't proof of gravitons in itself; a gravitational wave is many, many times more energetic than a graviton. But the waves could yet reveal the presence of these hypothetical particles, says de Rham.

We often think about the speed of light, but we don't think much about the speed of gravity – in other words, the speed at which gravitational waves travel. If gravitons are massless, then gravitational waves travel at light speed and nothing interesting happens. If, however, they have mass, then de Rham says we would expect lower frequencies of gravitational wave to move more slowly. At very low frequencies, that would create a kind of "gravitational rainbow" – so called because it would be similar to what happens when light is refracted by raindrops, albeit minus the colours.

We don't yet have sufficiently sensitive technology to detect the very low frequencies where these rainbows would show up. But if and when we do, we could look for them and, if we find them, that would be evidence not only that gravitons exist, but also that they have mass. "In my mind, there is no doubt that there should be a graviton," says de Rham. "But still, actually discovering it would be a big deal. It's definitely Nobel prize territory."

Today, de Rham is busy exploring whether her ideas about massive gravity could help to explain other mysteries of the cosmos too, such as dark energy – the mysterious force behind the accelerating expansion of the universe – and maybe even lead us to a deeper theory of gravity. We know that general relativity breaks down at very high energies, which suggests that there must be a better, more complete way to understand gravity.

"A graviton with mass might explain other mysteries, including dark energy"

Claudia de Rham takes flight while indoor skydiving

DAVID STOCK

"We know something has to come next," says de Rham. "We know that we don't even have the tools and the language to describe it, to understand how to ask ourselves the right questions. That may seem very daunting, but at the same time it is fascinating, because it tells us so much more is out there to be discovered."

On this topic, de Rham says that fundamental physics is currently undergoing a shift. Over the past decade or so, the field has been looking for physics beyond what we already know by testing ideas about specific new particles. But with all these efforts coming back empty-handed, we need ways to broaden the search, she says. "We are being pushed to chart out the parameter space that it is interesting and useful to look at."

Twisted waves

Her approach is to look at the characteristics that any standard unified theory, one that unites gravity with the other forces, would need to fit with the known laws of nature, and then to work back to see what consequences these would have that we could measure. To get your head around one aspect of this work, it helps to think of how photons of light can have two polarisations – either right or left handed – depending on how the light oscillates through space. If the graviton is massless, we would expect the same thing for gravitational waves – just two polarisations. If not, then there could be additional polarisations and de Rham has worked out that carefully measuring the properties of these extra polarisations could test certain kinds of more complete theories of physics, including string theory.

As we peel off our jumpsuits, some new punters arrive to train for an upcoming skydive. They are breathtakingly good, using small hand movements to somersault and spin their bodies through the air in synchrony. They will soon experience the force of gravity at its most visceral, throwing themselves out of a plane and hurtling towards Earth. "What connects it all," says de Rham, referring to her adventures in gravity, both physical and intellectual, "is really exploration." ▮

Joshua Howgego is deputy head of features at *New Scientist*

The back pages

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Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

Debunking gardening myths

Looking just vine

Ivy causes major structural damage to buildings and we should remove it whenever we can, right? Not so, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

Debunking gardening myths appears monthly

Next week
The science of baking

I AM always surprised by how often gardening, a pursuit ostensibly all about communing with nature, can be so driven by fear. One of the most common questions I get from concerned gardeners is how to remove the supposed scourge of climbing plants, like ivy, from walls. The thinking behind this is that climbers shatter brickwork and can cause profound structural damage to buildings. But when you actually look at the science, very few of these fears are based on any evidence. And frequently, the exact opposite is true.

In a 2020 study from the Royal Horticultural Society and the University of Reading, both in the UK, a range of climbing plants were found to have a protective effect on model brick buildings constructed for the experiment. The shade cast by the plants' leaves cooled the surface of the buildings in the summer by as much as 5.7°C, reducing the wide swings between day and night temperatures – a key driver of surface structural damage.

Despite concerns that plants trap moisture against brickwork, leading to damp issues, the same trial found this wasn't the case. Ivy didn't significantly raise humidity levels – rather, it helped stabilise them, minimising fluctuations that could damage the buildings' surfaces. The living coating also lowered summer temperatures inside the buildings by up to 7.2°C, and was even projected to reduce heating bills by as much as 20 per cent in the winter.

ANDREY KHOKHLOV/ALAMY

It is worth bearing in mind that these results were from brand new, model buildings with pristine brickwork. What about real-world, well-used buildings, whose exteriors may have already experienced centuries of environmental damage?

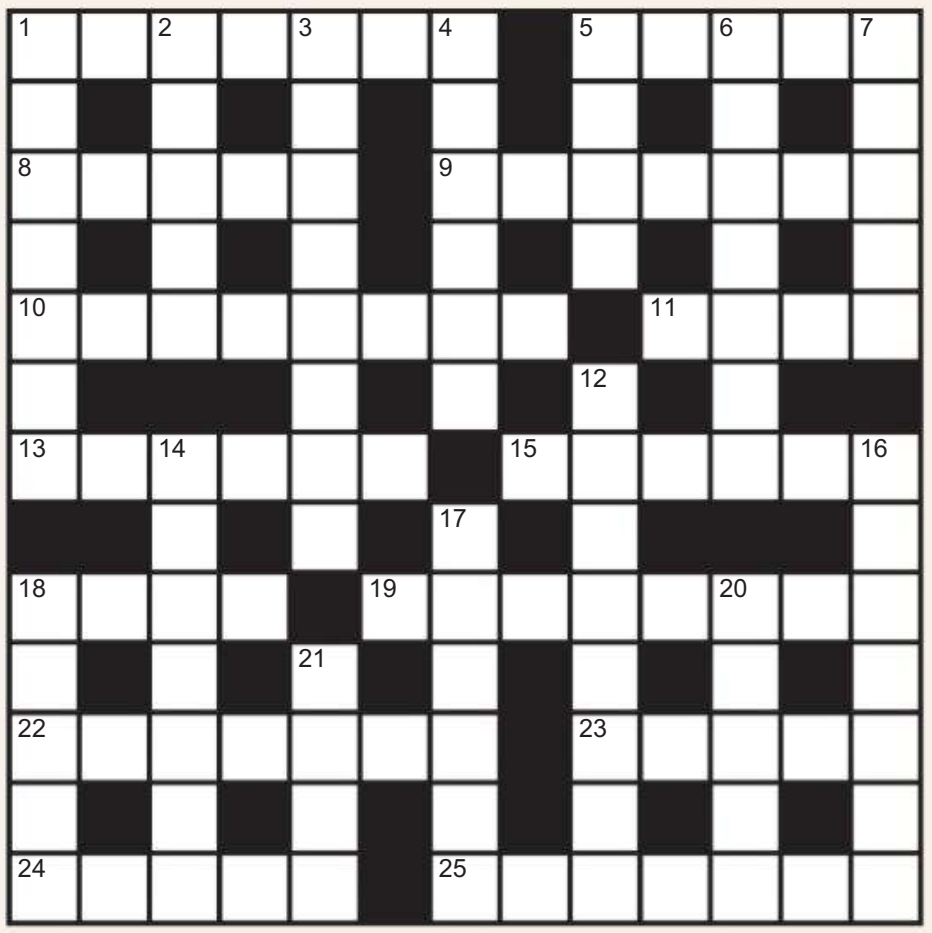
Well, another study, this one from 2011, found that in five historic buildings across England, bare walls experienced average maximum temperatures 36 per cent higher and minimum temperatures 15 per cent lower compared with those coated in a protective shroud of leaves.

The researchers concluded that the living insulation provided by ivy would "reduce the likelihood of frost and salt deterioration to the building materials, thus contributing to their conservation". They also found, in another study, that the leaves' ability to trap pollution could reduce the damage this can cause to historical walls, and even reduce human exposure to the noxious compounds in vehicle pollutants.

Imagine if there was a new material that could cool cities and cut energy bills, all while looking beautiful and costing a fraction of the price of alternatives. Did I mention it was also self-cleaning and carbon negative? The truth is that we have had this miracle material all along, but rather than appreciating it, we have spent huge amounts of time worrying about how to rip it out. ▮

These articles are posted each week at newscientist.com/maker

Cryptic crossword #132 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Charles formulated one of these cabbage salads after Georgia (3,4)
5 Drone accompanies an anthropoid (5)
8 Comment on nitrogen-deficient tree (5)
9 Amid two verbal stumbles, traitor makes mistake (7)
10 Weather event metrics roughly encompassing globe (3,5)
11 Addendum consists of wave function symbols (4)
13 Photo finish disheartened guy broken by defeat (6)
15 Wet hairstyle, no longer new (6)
18 With backing, release quantum systems when paired with 19 Across (4)
19 Stones tear up rotten slats (8)
22 Despicable Jack caught by number one dog (7)
23 Money went fast in football club (5)
24 Fund space at chemical company (5)
25 Lecoq's discovery is good with onion or garlic (7)

DOWN

1 Go around large annex with a happy expression (7)
2 Spear second freshwater fish (5)
3 American raised biting fly for mutagen assay (4,4)
4 Listened to clips: "It's curtains" (6)
5 Damage hard branch (4)
6 German with family member supporting doughnut division (7)
7 Freezes protuberances surrounding mass (5)
12 Cocky but also worried about failing grade (8)
14 Operating system demos unfortunately crossed a barrier (7)
16 Police car's recording device writing up physicist Ernst (sorry) (4,3)
17 Vexing feature of their kingdom (6)
18 List left half-finished under nocturnal mammal in its sleeping position? (5)
20 Game company put dark stuff into AI (5)
21 Female pig swallows unknown powder (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #245
set by Bethan Ackerley

1 Which neuropeptide did Ulf von Euler and John Gaddum discover in 1931?

2 Epistaxis is bleeding from where?

3 In genetics, the expression of multiple traits by a single gene is known as what?

4 The interpretation of quantum mechanics espoused by Niels Bohr and others from the mid-1920s is named after which city?

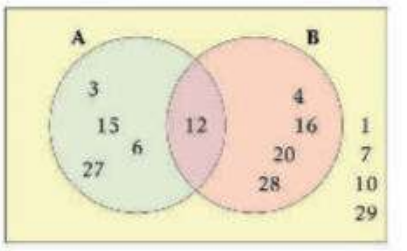
5 The space between a tooth and the surrounding gum is known as what?

Answers on page 47

BrainTwister
set by Peter Rowlett
#13 Number Venns

Numbers 1–30 are put in circle A if they are part of group A, in circle B if they belong to group B, in the intersection between if they are part of both A and B, or outside the circles if they don't belong to either A or B. What are groups A and B for each diagram below (not all numbers have been placed yet)?

Only one of these diagrams can have another number added to the overlapping section using these rules. Which one is it and what is the number?

1.


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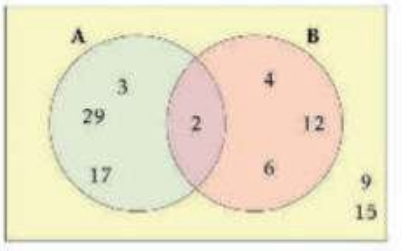

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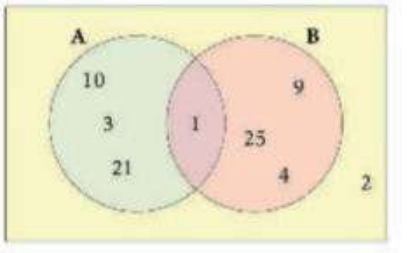

Solution next week

Bright spring

Why are so many spring flowers yellow, with other colours (such as blues and reds) appearing later?

Mike Follows
Sutton Coldfield, West Midlands, UK
The first flowers of spring are often white or yellow due to what pollinates them: a broad range of insects, including flies. Flies don't have colour perception, so they are attracted to contrast, and light colours stand out better against green foliage.

Though perhaps apocryphal, it is said that John Hertz, famous for starting the Yellow Cab Company in 1915 (and his subsequent eponymous car-hire business), decided on the iconic yellow colour for his cabs as a result of a survey he commissioned, which suggested that yellow is the colour most easily seen at a distance. Perhaps this also applies to pollinating insects.

Yellow pigment is also cheaper to produce, in energy terms, than other colours. Perhaps some species of plant have evolved to take advantage of this to get their billboards out early.

"John Hertz is said to have chosen yellow for his cabs after a survey suggested it is the colour most easily seen at a distance"

Hazel Russman
London, UK
Yellow flowers attract butterflies, which are some of the first insects to come out in spring, after hatching from overwintering chrysalises. Blue flowers are actually not far behind (think of yellow and blue crocuses). They have evolved to attract bees, as blue is in the middle of a bee's visual spectrum. But it takes a little while longer for a hibernating beehive to wake up properly.

A wasp's nest only comes fully on stream in high summer, as it starts from a single queen. Wasps have powerful jaws to cut up other insects for their carnivorous young, and this also allows them to pierce the skins of soft fruits and steal their sweet juices.

Since most fruits advertise their ripeness to passing birds by turning from green to red, wasps have developed optical receptors for red light (which bees lack). And some flowers seem to have taken advantage of this.

David Muir
Edinburgh, UK
At least in Europe, bumblebees are the first pollinators that people tend to notice in early spring. Usually this is the buff-tailed bumblebee, *Bombus terrestris*, which I have seen around Edinburgh in mid-February. But there are unnoticed pollinators buzzing around before *B. terrestris*; these are flies, and they provide their pollinating services to early spring flowers. Flies have poor colour vision but can differentiate light and dark, so they are attracted to the white and yellow flowers that brighten our late winter days.

Co-evolution is often thought of as a selective evolutionary pressure between two species. But there is also multi-species or diffuse co-evolution. This is where a number of similar species (in this case flies) develop a trait in reciprocity with traits in another group of species (white and yellow flowers), resulting in a mutual symbiosis. Flies better attracted to bright yellows and whites feed better, so they are more able to pass on their genes. And flowers that are more attractive to flies benefit from enhanced pollination.

Peg McCann
St Joseph, Michigan, US
As with so much in life and in science, the answer depends on what is meant by "so many". The photo of garden beds full of daffodils that accompanied this question illustrates the quick answer: among spring-flowering garden plants, daffodils are common, mainly yellow and large. They also persist decades after planting, at least here in Michigan. An abandoned house may crumble with time, but the daffodils around it remain.

Another way to answer the question defines "so many" by number of species. Years ago, I used some US wildflower guides to tally each species by bloom colour and month. Species with white or whitish flowers generally bloom a few weeks earlier than those with yellow flowers. I also found that the number of species in bloom with blue flowers is about constant from May to September. Habitat may explain part of this. As many will have noted, plants in wooded areas bloom earlier (before the tree canopy closes) than plants in open spaces, and plants in wooded habitats have disproportionately pale blooms.

Simon Mitchell
London, UK
I read this question last week with bemusement as I looked out at the purple crocuses in my garden. Today, after a night of carnage instigated by our local grey squirrels, I no longer have any crocuses. I instead look out over the emerging yellow daffodils that it seems the squirrels dislike the taste of.

Next year I will only plant yellow daffodils, as I expect many gardeners have learned to do the hard way.

SHUTTERSTOCK/LONGTAILDOG

Have migrating animals been confused by the shifting position of magnetic north?

This week's new questions

Going north **Earth's north magnetic pole is moving from Canada towards Siberia. Has there been a noticeable effect on migrating animals that sense the geomagnetic field as a navigation aid?** ***Bob Werner****, Pasadena, California, US*

Ironed out **Why is it harder to remove a crease from a shirt with an iron than to put one in?** ***Matthew Bradby****, London, UK*

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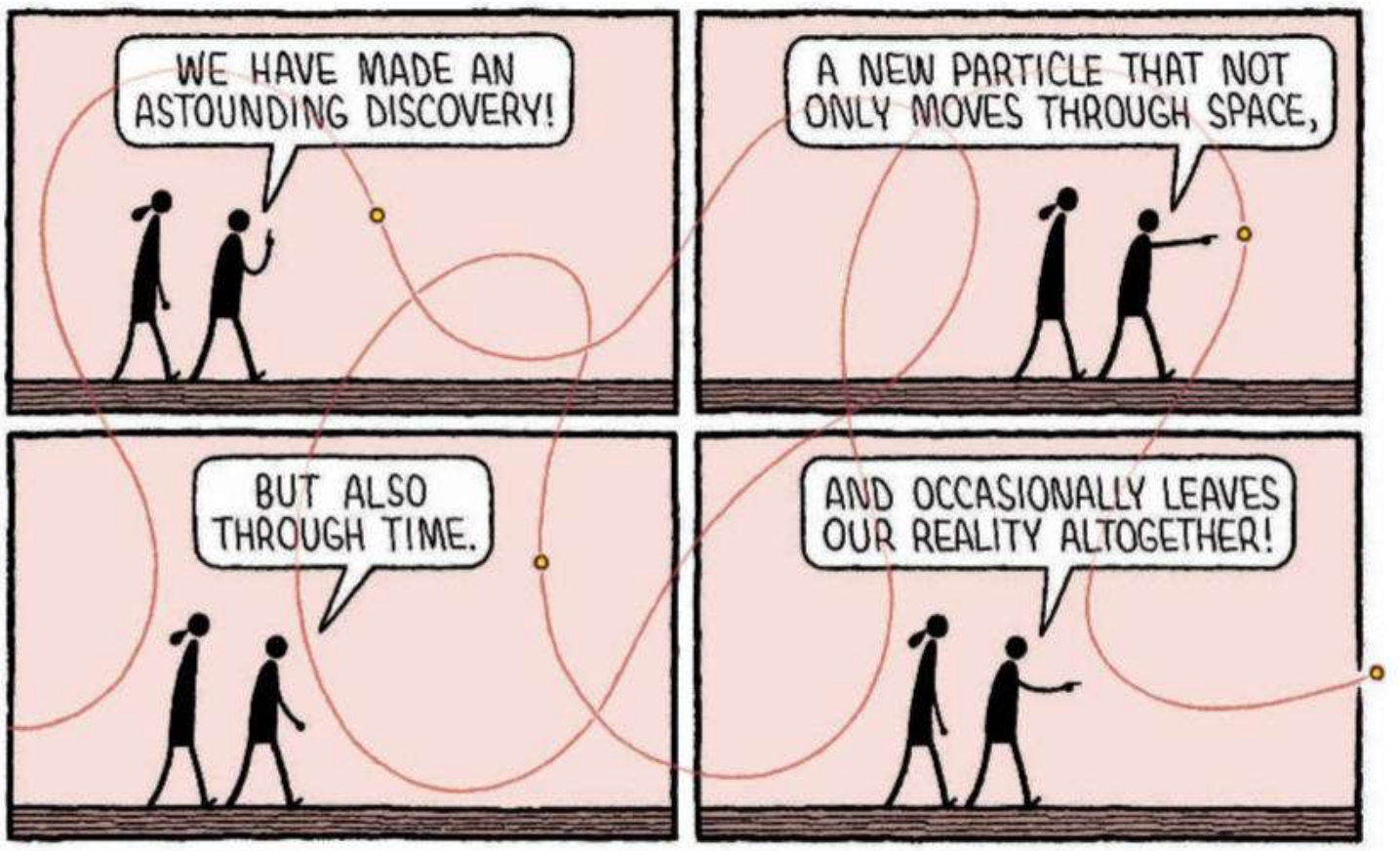
Tom Gauld
for New Scientist


WE HAVE MADE AN ASTOUNDING DISCOVERY!
A NEW PARTICLE THAT NOT ONLY MOVES THROUGH SPACE,
BUT ALSO THROUGH TIME.
AND OCCASIONALLY LEAVES OUR REALITY ALTOGETHER!

Crash course

If the Milky Way were to collide with another galaxy, how would it affect day-to-day life on Earth?

Herman D'Hondt
Sydney, Australia

The short answer to the question is "probably not at all". The long answer is more complicated.

The average distance between stars in our galaxy is about 5 light years (ly). This is roughly the same as the distance of 4.25 ly to our nearest stellar neighbour, Proxima Centauri. Stars don't significantly affect each other gravitationally unless they are less than 2 ly apart. That means that, when another galaxy collides with ours, the stars will typically be too far apart to affect each other's planets.

If a star did get close enough to us, it could change the orbit of Earth and push us either closer to the sun or further from it. Any shift like that would make global warming seem trivial. If this did happen, we would see it coming for many thousands of years. The Andromeda galaxy, the closest spiral galaxy to ours, is moving towards us at about 110 kilometres per second, and the collision is about 4 billion years away, so we have plenty of time to take action.

"By the time any of this happens, the sun will be running out of fuel and will have swollen enough that Earth will be burned to a crisp"

Another possible problem concerns the gas clouds in both galaxies. When these collide, the resulting pressure waves trigger furious star creation. Some of these new stars will be massive and will quickly burn out and go supernova. If such an explosion were to happen within 50 ly of Earth, the radiation released would profoundly affect life. However, even the most massive stars take a few million years to go "super". So, again, there is time to prepare.

Finally, there are the supermassive black holes at the centre of each galaxy. Even if we don't collide with the black hole at the centre of the incoming galaxy (which would be uniformly bad for life as we know it), the two galactic cores would eventually merge. That may cause the resulting black hole to become active and spew out radiation that could affect life. The collision would also affect the orbits of stars around the galaxy.

However, by the time any of this happens, the sun will have started to run out of fuel and will have swollen so much that Earth will be burned to a crisp. In other words, we will have more pressing things to worry about.

Guy Cox
Sydney, Australia

Galaxies are mostly empty space, so the chances of anything hitting us are slim. Earth would continue to rotate around the sun, and our seasons would be unchanged. What would be different would be the night sky. The constellations would be totally changed. If you believe in your birth zodiac sign you would be in trouble, since it would no longer exist. ▮

Answers

Quick quiz #245 *Answers*

1 Substance P
2 The nose
3 Pleiotropy
4 Copenhagen
5 The gingival sulcus

Quick crossword #154 *Answers*

ACROSS 1 Work, **3** Blood group, **10** Viewing, **11** Bimodal, **12** Lab coat, **13** Thorny, **15** Nodes, **16** Echolalia, **18** *The Matrix*, **21** Manic, **23** Osprey, **25** Helical, **27** Plateau, **28** Die-cast, **29** Cryptogram, **30** Bear

DOWN 1 Wavelength, **2** Reed bed, **4** Light year, **5** Orbit, **6** Gumboil, **7** Ordinal, **8** Palp, **9** Pivots, **14** Calculator, **17** Hexahedra, **19** Ecstasy, **20** Air vent, **21** Mildew, **22** Nictate, **24** Young, **26** Spec

#12 Factorial factory *Solution*

A zero will be present at the end of a number if it is divisible by 2 and 5, as this means it is divisible by 10. If a number has two factors of 5 and 2, it will be divisible by 100 and have two zeros on the end. When making factorials, we multiply numbers together. Each time we multiply by 5 or a number divisible by 5, we introduce a factor of 5. As every second number we multiply by is even, we will always have enough factors of 2 to pair with the 5s – so the number of zeros on the end is determined by the number of factors of 5. For 10!, we multiply by 5 and 10, so have two factors of 5, giving two zeros on the end. 25! has six zeros (multiplying by 25 gives us two factors of 5), and 1066! has 264 zeros (three 5s for 125 and four for 625).

Berate the refs

There is new evidence that it can pay to scream at referees in sports stadiums. That evidence appears in the study "Verbal aggressions against Major League Baseball umpires affect their decision making", by Joël Guérette, Caroline Blais and Daniel Fiset at the University of Quebec in Outaouais, Canada. They published it in the journal *Psychological Science*.

Guérette, Blais and Fiset probed data from 10 years of major league professional baseball games. These games, they stress, unfold in "an ecological environment where excessive criticism is rampant".

They detected what they call "a two-sided benefit of resorting to verbal abuse". After being severely criticised, "home-plate umpires were less likely to call strikes to batters from the complaining team and more prone to call strikes to batters on the opposing team".

B. McGraw (first name unspecified) brought this to Feedback's attention, impressed by the deployment of disciplined academic speak when the authors say: "Our findings support the hypothesis that, under certain conditions, verbal aggression may offer an advantage to complainants."

Your ice cream nozzle

Questions arise when things start growing on your nozzle – questions that grow less pressing if you diligently clean the nozzle after you use it to dispense a serving of ice cream. Because if you don't clean a food machine's nozzle and other parts, things get a healthy (from the things' point of view) chance to grow on them.

Psychrotrophs are bacteria that can grow at low temperatures – temperatures that might be found, say, inside refrigerators or freezers.

A study called "Psychrotrophic bacteria equipped with virulence and colonization traits populate the ice cream manufacturing environment" brings up the necessity of nozzle-tending.

The discussion aims to forestall horror stories. The authors, at the University of Naples Federico II in Italy, say: "We provide evidence of the existence of complex microbial communities overcoming sanitation in an ice cream-producing facility." Harken, therefore, ice creamer. Tend your nozzle.

Twisteddoodles *for New Scientist*

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Your chocolate nozzle

Unexpected, vaguely related questions can arise when you consider what shape of nozzle to use for, say, 3D printing chocolate. A study in *Frontiers in Psychology* looks at one question that is surprisingly subtle and complex: how much chocolate is too much chocolate when it comes to matters of taste? The study is called "The influence of bouba- and kiki-like shape on perceived taste of chocolate pieces".

"Bouba" and "kiki" are concocted words that, some psychological experiments suggest, somehow evoke notions of shape. To many, "bouba" seems curvy and "kiki" seems spiky. The researchers found evidence that bouba can taste subtly sweeter than kiki, but to measure that distinction, they had to restrict the amount of chocolate in a bite.

They write: "Prior studies found no differences in participants' reports of taste differences following actual consumption of round and angular chocolate pieces. We assumed that the amount of chocolate eaten in this prior study was too large, which caused the actual taste to dominate any effect of perceived shape on taste."

They engineered a solution: "We designed a ring-shaped stimulus that was not filled with chocolate at its center to avoid the need to consume excessive chocolate taste/flavor, while maintaining perceived differences in shape."

Using sweeter-tasting shapes to reduce chocolate consumption, they say, would benefit even non-chocolate-eaters by reducing the production of chocolate and thus of greenhouse gases. By implication, bouba/kiki-aware chocolate-dispenser nozzle selection can be a not-just-symbolic weapon in the struggle against global warming.

Your bevelled nozzle

Bevel your nozzles, if you insist on equipping your jet aircraft with turbofan engines – and if quiet is what you seek. Bevel them. That's the word from Julien Christophe, Julien de Decker and Christophe Schram at the von Karman Institute for Fluid Dynamics in Belgium. Writing in *Flow, Turbulence and Combustion*, they explain why: "Beveled nozzles achieve a noise reduction for all radiation angles with a maximum decrease up to 2 dB at receiver locations perpendicular to the plate." For tranquility's sake, bevel.

Crypto-emojis

If there is a competition for most jargon-dense research writing about sketchy financial undertakings, maybe put your cryptocurrency on a study called "Emoji driven crypto assets market reactions", by Xiaorui Zuo, Yao-Tsung Chen and Wolfgang Karl Härdle.

The word "pith" is sometimes defined as "the spongy white tissue lining the rind of oranges and other citrus fruits". This study includes a pithy description of itself: "We leverage GPT-4 and a fine-tuned transformer-based BERT model for a multimodal sentiment analysis, focusing on the impact of emoji sentiment on cryptocurrency markets." The paper doesn't say what "BERT" is. The paper does say: "Similar sentiment analysis techniques could be applied to broader financial markets." ▮

Marc Abrahams

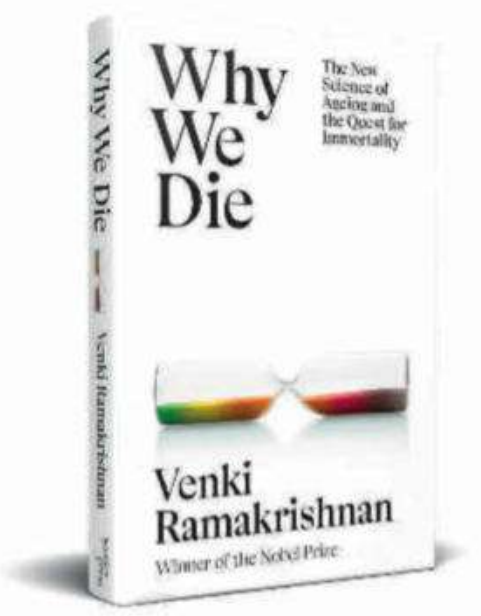
Do you want to live forever?

We are living through a revolution in biology. For the first time, recent research on the fundamental causes of ageing is raising the prospect not merely of improving our health in old age but also of extending human life span.

For centuries, our life expectancy hardly changed. But over the last 150 years, we have doubled it, primarily because we better understand disease and its spread. This has allowed us to make enormous strides in extending our average life span. **But extending maximum life span – the longest we can expect to live even in the best of circumstances – is a much tougher problem.** Is our life span fixed, or could we slow down or even abolish ageing as we learn more about our own biology?

In the last ten years alone, more than 300,000 scientific articles on ageing have been published. **More than 700 start-up companies have invested a combined many tens of billions of dollars to tackle ageing.** This enormous effort raises huge questions. Could we eventually cheat disease and death and live for a very long time, possibly many times our current life span?

The immortality merchants of today – **the researchers who propose trying to extend life indefinitely and the billionaires who fund them – are really a modern take on the prophets of old,** promising a long life largely free of the fear of encroaching old age and death. Who would have this life? The tiny fraction of the population who could afford it? What would be the ethics of treating or modifying humans to achieve this? And if it becomes widely available, what sort of society would we have? **We must ask where this research is leading us, as well as what it suggests about the limits of human beings.**



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